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Office of Radiation Programs

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭ'lo
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
A	ampere(s)	
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps-2.22×10^{12} dpm
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	3.527×10^{-2} ounces= 2.205×10^{-3} pounds
Hz	hertz	cycle per second
kVp	kilovolt peak	
m	meter(s)	39.4 inches
m^3	cubic meter(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
mi	mile(s)	
ml	milliliter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g
s	second	

RADIATION DATA AND REPORTS

Volume 14, Number 9, September 1973

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

- Department of Defense
- Department of Agriculture
- Department of Commerce
- Department of Health, Education, and Welfare
- Environmental Protection Agency
- Atomic Energy Commission

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U.S. ENVIRONMENTAL PROTECTION AGENCY
Russell E. Train, Administrator

Reports

Environmental Monitoring and Disposal of Radioactive Wastes from U.S. Naval Nuclear-Powered Ships and Their Support Facilities, 1972

M. E. Miles and G. L. Sjoblom[1]

The environmental effect of disposal of radioactive wastes originating from U.S. Naval nuclear propulsion plants and their support facilities is assessed. The total radioactivity discharged to all ports and harbors from the more than 100 nuclear-powered ships and supporting tenders, bases and shipyards was less than 0.002 curie in 1972. This report confirms that procedures used by the Navy to control releases of radioactivity from U.S. Naval nuclear-powered ships and their support facilities are effective in protecting the environment and the health and safety of the general public.

The radioactivity in wastes discussed in this report originates in the pressurized water reactors of U.S. Naval nuclear-powered ships. As of the end of 1972, there were 100 nuclear-powered submarines and 4 nuclear-powered surface ships in operation. Support facilities involved in construction, maintenance, overhaul and refueling of these nuclear propulsion plants include 9 shipyards, 11 tenders, and 2 submarine bases. This report describes disposal of radioactive liquid wastes, disposal of solid wastes and monitoring of the environment to determine the effect of radioactive releases. This report concludes that radioactivity associated with U.S. Naval nuclear-powered ships has had no significant or discernible effect on the quality of the human environment. A summary of radiological environmental information supporting this conclusion follows.

From the start of the Naval nuclear propulsion program, the policy of the U.S. Navy has been to reduce to the minimum practicable the amounts of radioactivity released into harbors. Navy procedures to accomplish this have been reviewed with the U.S. Atomic Energy Commission (AEC) and the U.S. Environmental Protection Agency (EPA). The total radioactivity discharged within 12 miles from shore from all U.S. Naval nuclear-powered ships and their support facilities in recent years is shown in table 1.

As a measure of the significance of these data, if one person were able to drink the entire amount of radioactivity discharged into any harbor in 1972, he would not exceed the annual individual radiation exposure permitted by the U.S. Atomic Energy Commission for its employees and licensees.

Table 1. Total radioactivity discharged within 12 miles from shore from all U.S. Naval nuclear-powered ships and their support facilities, 1968–1972

Year	Number of ships in operation	Volume (1,000 gallons)	Radioactivity less tritium (curies)
1968	84	3,691	0.081
1969	91	3,326	.048
1970	96	2,571	.024
1971	100	1,089	<.002
1972	104	289	<.002

Extensive environmental monitoring is conducted by the Navy in the United States and foreign harbors frequented by nuclear-powered

[1] Nuclear Power Directorate, Naval Ship Systems Command, Department of the Navy.

ships. This monitoring consists of collecting and analyzing harbor water and sediment samples for radioactivity associated with Naval nuclear propulsion plants, radiation monitoring around the perimeter of support facilities and effluent monitoring. The EPA has conducted independent surveys, the results of which have been consistent with Navy results. These surveys have confirmed that U.S. Naval nuclear-powered ships and support facilities have had no significant effect on the radioactivity of the marine environment.

Radioactive liquid waste disposal

Policy and procedures minimizing release of radioactivity in harbors

The policy of the U.S. Navy is to reduce to the minimum practicable the amounts of radioactivity released within 12 miles from shore including into harbors. This policy is consistent with applicable recommendations issued by the Federal Radiation Council (incorporated into the Environmental Protection Agency late in 1970), U.S. Atomic Energy Commission, National Council on Radiation Protection and Measurements, International Commission on Radiological Protection (ICRP), International Atomic Energy Agency, and National Academy of Sciences—National Research Council (*1-7*). Keeping releases small minimizes the radioactivity available to build up in the environment or to concentrate in marine life. To implement this policy of minimizing releases, the Navy has issued standard instructions defining the radioactive waste disposal limits and procedures to be used by U.S. Naval nuclear-powered ships and their support facilities. These instructions were reviewed and concurred in by the AEC and the Public Health Service (PHS). The radiological surveillance organization of PHS has since been moved to the EPA.

Source of radioactivity

In the shipboard reactors, pressurized water circulating through the reactor core picks up the heat of nuclear reaction. Reactor cooling water circulates through a closed piping system to heat exchangers which transfer the heat to water in a secondary steam system isolated from the primary cooling water. The steam is then used as the source of power for the propulsion plant as well as for auxiliary machinery. Releases from ships occur primarily when reactor coolant water expands as a result of being heated to operating temperature; this coolant passes through a purification sys-

Table 2. Radioactive liquid waste released to harbors from U.S. Naval nuclear-powered ships and their support facilities for 1968 through 1972[a]

Facility	1968		1969		1970		1971		1972	
	(Volume Thousand gallons)	(Radioactivity Curies)	(Volume Thousand gallons)	(Radioactivity Curies)	(Volume Thousand gallons)	(Radioactivity Curies)	(Volume Thousand gallons)	(Radioactivity Curies)	(Volume Thousand gallons)	(Radioactivity Curies)
Portsmouth, N.H.; Naval Shipyard	171	0.006	87	0.002	68	0.002	51	<0.001	25	<0.001
Groton-New London, Conn; Electric Boat Division, Tender at State Pier and Sub Base	469	.006	615	.006	359	.004	258	<.001	151	<.001
Newport News, Va; Newport News Shipbuilding	1,146	.025	870	.022	1,466	.013	262	<.001	13	<.001
Norfolk, Va; Naval Shipyard and Tender	184	.004	102	.005	98	.001	38	<.001	18	<.001
Charleston, S.C.; Naval Shipyard and Tenders	227	.004	131	.001	58	<.001	45	<.001	8	<.001
Pascagoula, Miss; Ingalls Nuclear Division	9	<.001	8	<.001	7	<.001	28	<.001	12	<.001
San Diego, Calif; Tenders at Ballast Point	<1	<.001	<1	<.001	<1	<.001	<1	<.001	<1	<.001
Long Beach, Calif; Naval Shipyard and Base	<1	<.001	2	<.001	<1	<.001	<1	<.001	<1	<.001
Vallejo, Calif; Mare Island Naval Shipyard	391	.027	80	.001	121	.002	219	<.001	7	<.001
Bremerton, Wash; Puget Sound Naval Shipyard	182	.001	152	.001	136	<.001	98	<.001	16	<.001
Pearl Harbor, Hawaii, Naval Shipyard and Sub Base	886	.006	1,279	.008	258	.002	90	<.001	38	<.001
Apra Harbor, Guam	26	.001	<1	<.001	<1	<.001	<1	<.001	<1	<.001
All other harbors, United States and foreign	<1	<.001	<1	<.001	<1	<.001	<1	<.001	<1	<.001
Total	3,691	0.081	3,326	0.048	2,571	0.024	1,089	<0.002	289	<0.002

[a] Radioactivity data have been standardized to cobalt-60 and excludes tritium. Volumes are prior to dilution. A total of 0.02 curie was discharged into the river at Quincy, Mass. from 1961 through March 1969 when all work on U.S. Naval nuclear-powered ships was discontinued at General Dynamics, Quincy Division. Slight differences in volumes and radioactivity data from past reports result from using more significant figures in this table. Volumes less than 500 gallons are shown as <1 thousand. Curies less than 0.0005 are shown as <0.001.

tem ion exchange resin bed prior to being transferred from the ship.

The principal source of radioactivity in liquid wastes is from neutron activation of trace amounts of corrosion and wear products from reactor plant metal surfaces in contact with half-lives greater than 1 day in these corrosion and wear products include tungsten-187, chromium-51, hafnium-181, iron-59, iron-55, zirconium-95, tantalum-182, manganese-54, cobalt-58, and cobalt-60. The predominant and also longest-lived of these is cobalt-60, which has a 5.3 year half-life; cobalt-60 also has the most restrictive concentration limit in water listed by organizations which set radiological standards in references *1-3* for these corrosion and wear radionuclides. Therefore, radioactive waste disposal is conservatively controlled by assuming that all long-lived radioactivity is cobalt-60.

Support facilities are equipped with processing systems to remove most of the radioactivity from liquid waste prior to release into harbors. These liquid wastes result from transferring water from ships as well as decontaminating radioactively contaminated piping systems and laundering anticontamination clothing worn by personnel.

Liquid waste releases in harbors

The total amounts of long-lived radioactivity released into harbors and seas within 12 miles from shore during the past 5 years are summarized in table 2, which updates information in references *8-14*. Included are data on releases from U.S. Naval nuclear-powered ships and from supporting shipyards, tenders, and submarine bases. Locations listed in table 2 include all operating bases and home ports in the United States and overseas as well as all other ports which have been visited by Naval nuclear-powered ships. The quantities of radioactivity listed in this table are conservatively reported as if the entire radioactivity consisted of cobalt-60, which is the predominant long-lived radionuclide and also has the most stringent concentration limits.

Although this table shows both volume and curies released, the curie data are the more significant. In 1972, the volumes shown in table 2 for these organizations were no more than many single United States homes release to their sewage systems each year. The volume released has been reduced over several years by reducing waste generation as well as reuse of liquids after processing.

Table 3. Total radioactive liquid waste released at sea by all U.S. Naval nuclear-powered ships and supporting tenders

Year	Volume (thousand gallons)	Radioactivity (Ci)
1968	1,630	1.1
1969	1,570	1.7
1970	1,220	.8
1971	1,840	.8
1972	1,970	.6

The table shows that the total amount of radioactivity released within all United States and foreign harbors by the more than 100 nuclear-powered ships in the U.S. Navy was less than 0.002 curie. Nearly all the radioactive releases occur where shipyards are overhauling nuclear-powered ships. To put this small quantity of radioactivity into perspective, it is less than the quantity of naturally occurring radioactivity (*15*) in the volume of saline harbor water occupied by a single nuclear-powered submarine. This small amount of radioactivity has had no significant or discernible effect on the quality of the human environment.

Other radionuclides

Reactor coolant also contains short-lived radionuclides with half-lives of seconds to hours. Their highest concentrations in reactor coolant are from nitrogen-16 (7 second half-life), nitrogen-13 (10 minute half-life), fluoride-18 (1.8 hour half-life), argon-41 (1.8 hour half-life) and manganese-56 (2.6 hour half-life). For the longest-lived of these, about 1 day after discharge from an operating reactor the concentration is reduced to one thousandth of the initial concentration and in about 2 days the concentration is reduced to one millionth. Most liquid releases from ships occur during heating up prior to extensive power operation of the reactor, when short-lived radioactivity in such a release is less than 0.001 curie. Because of their small amounts and rapid decay, short-lived radionuclides are insignificant compared to

long-lived radionuclides for waste disposal considerations.

Fission products produced in the reactor are retained within the fuel elements. The fission gases, krypton and xenon, are also retained within the fuel elements. However, trace quantities of naturally occurring uranium impurities in reactor structural materials release small amounts of fission products to reactor coolant. The concentrations of fission products and the volumes of reactor coolant released are so low, however, that the total radioactivity attributed to long-lived fission product radionuclides, strontium-90 and cesium-137, in releases from U.S. Naval nuclear-powered ships and their support facilities has been less than 0.001 curie per year for all harbors combined. Fallout of these same fission products has often been more than this in one rainfall in a single harbor.

Tritium

Small amounts of tritium are formed in reactor coolant systems as a result of neutron interaction with the approximately 0.015 percent of naturally occurring deuterium present in water, and other nuclear reactions. Although tritium has a 12-year half-life, the radiation produced is of such low energy that the radioactivity concentration guide issued by the ICRP, AEC, and by other standard-setting organizations is 100 times higher for tritium than for cobalt-60. This tritium is in the oxide form and chemically indistinguishable from water; therefore it does not concentrate significantly in marine life or collect on sediment as do other radionuclides.

Tritium is naturally present in the environment because it is generated by cosmic radiation in the upper atmosphere. Reference *16* reports that the production rate from this source is about 6 million curies per year, which through rainfall produces a tritium inventory in the oceans of about one hundred million curies. Because of this naturally occurring tritium, much larger releases of tritium than are conceivable from Naval reactors would be required to make a measurable change in the background tritium concentration.

The total amount of tritium released during each of the last 5 years from all U.S. Naval nuclear-powered ships and their supporting tenders, bases and shipyards has been less than 200 curies. Most of this has been into the ocean greater than 12 miles from shore. This total tritium from the entire nuclear Navy is less than typical electrical generating nuclear power stations release each year (*17*). Such releases are too small to increase measurably the tritium concentration in the environment. Therefore, tritium has been excluded from the data in other sections of this report.

Liquid waste releases at sea

Radioactive liquid wastes are also released at sea under strict controls. These ocean releases are consistent with the recommendations the Council on Environmental Quality made in 1970 to the President (*18*). Procedures and limits for ocean disposal have been consistent with recommendations made by the National Academy of Sciences—National Research Council (*5*) and by the International Atomic Energy Agency (*6*).These releases have contained much less radioactivity than these reports considered would be acceptable. Total long-lived radioactivity excluding tritium, released farther than 12 miles from shore by U.S. Naval nuclear-powered ships and supporting tenders is shown in table 3 for recent years. This is the total amount released from over 100 ships at different times of the year in the open sea at long distances from land in small incremental amounts, and under rapid dispersal conditions due to wave action. Therefore, the radioactivity reported in table 3 has no significant effect on the radioactivity of the marine environment.

Solid radioactive waste disposal

During maintenance and overhaul operations, solid low-level radioactive wastes consisting of contaminated rags, plastic bags, paper, filters, ion exchange resin and scrap materials are collected by nuclear-powered ships and their support facilities. High-level radioactive wastes are associated with expended reactor fuel all of which is transferred to the AEC for processing ashore.

Solid radioactive materials from Naval nuclear-powered ships are not dumped at sea

Table 4. Radioactive solid waste from U.S. Naval nuclear-powered ships and their support facilities for 1968 through 1972[a]

Facility	1968		1969		1970		1971		1972	
	Volume (thousand cubic feet)	Radioactivity (curies)	Volume (thousand cubic feet)	Radioactivity (curies)	Volume (thousand cubic feet)	Radioactivity (curies)	Volume (thousand cubic feet)	Radioactivity (curies)	Volume (thousand cubic feet)	Radioactivity (curies)
Portsmouth, N.H; Naval Shipyard	31	151	8	3	14	16	12	9	9	4
Groton, New London, Conn; Electric Boat Div., Tender at State Pier and Sub Base	4	21	8	328	12	140	18	13	7	6
Newport News, Va; Newport News Shipbuilding	14	10	17	382	28	312	21	165	10	8
Norfolk, Va; Naval Shipyard and Tender	2	11	6	8	9	146	10	33	10	1,026
Charleston, S.C; Naval Shipyard and Tenders	14	110	15	9	8	6	6	4	7	34
Pascagoula, Miss; Ingalls Nuclear Division	0	0	1	<1	0	0	2	<1	2	2
San Diego, Calif; Tenders at Ballast Point	1	8	<1	2	<1	1	2	<1	<1	<1
Long Beach, Calif; Naval Shipyard and Base	<1	<1	<1	<1	<1	<1	1	<1	<1	<1
Vallejo, Calif; Mare Island Naval Shipyard	8	7	8	5	12	2	22	25	9	13
Bremerton, Wash; Puget Sound Naval Shipyard	14	48	11	42	18	1,327	21	59	9	22
Pearl Harbor, Hawaii; Naval Shipyard and Sub Base	3	6	4	3	5	4	4	2	4	147
Total	92	372	78	783	106	1,954	119	311	67	1,262

[a] This table includes all radioactive waste from tenders and nuclear-powered ships. This radioactivity is primarily cobalt-60. This radioactive waste is shipped to burial facilities licensed by the USAEC or State. Slight differences from past reports result from using different number of significant figures in this table. Volumes less than 500 cubic feet are reported as <1 thousand and less than 0.5 curie is reported as <1 curie.

since the Navy procedures prohibit sea disposal of solid radioactive materials. Solid radioactive waste materials are packaged in strong tight containers, shielded as necessary and shipped to burial sites licensed by the AEC or a State under agreement with the AEC. Shipyards and other shore facilities are not permitted to dispose of radioactive solid wastes by burial on their own sites. The Navy procedures require all packaging and shipping of radioactive materials to be perfomed in strict compliance with U.S. Department of Transportation and AEC requirements.

Table 4 summarizes total radioactivity and volumes of radioactive solid waste disposal for the last 5 years. Table 4 does not include expended fuel which is processed by the AEC at special facilities ashore.

Because of efforts to minimize solid waste and the utilization of compaction equipment, total volumes have remained nearly constant in spite of increasing work caused by increasing number of ships. The average annual volume for the entire Naval nuclear propulsion program could be contained in a cube measuring 15 yards on a side. The radioactivity does not require excessively long time care in the licensed burial ground since the principal radionuclides do not have half-lives longer than 5 years. In 100 years, such radioactivity will have decayed to one millionth the initial radioactivity. In less than 200 years, the total of all radioactivity conservatively assumed to be cobalt-60 in table 4 will have decayed to less than one millionth of a curie and would not be detectable in the burial grounds using sensitive instruments.

Environmental monitoring

To provide additional assurance that procedures used by the U.S. Navy to control radioactivity are adequate to protect the environment, the Navy conducts an extensive environmental monitoring program in harbors frequented by nuclear-powered ships. Environmental monitoring surveys for radioactivity are periodically performed in harbors where U.S. Naval nuclear-powered ships are built or overhauled and where these ships have home ports or operating bases. To ensure thoroughness and objectivity, these surveys are made as independent as practicable from waste disposal operations. Samples from each harbor monitored are also checked at least annually by an AEC laboratory to ensure that analytical procedures are correct and standardized. These AEC laboratory results have been consistent with shipyard and operating base results. As a further independent check of environmental monitoring, a laboratory of the Environmental Protection Agency (formerly part of U.S. Public Health Service) has conducted detailed surveys of selected harbors (*19-21*). This laboratory has monitored the harbors at Charleston, S.C; Pearl Harbor, Hawaii; San Diego, Calif; Vallejo, Calif; New London, Conn; Newport

News, Va; and Norfolk, Va. Navy monitoring results have been consistent with these survey results.

The current Navy environmental monitoring program consists of the analysis of samples of harbor water and sediment, supplemented by shoreline surveys, film badge analysis and effluent monitoring.

Five water samples are taken in each harbor once each quarter year in areas where nuclear-powered ships berth and from upstream and downstream locations. These samples are analyzed for gross gamma radioactivity and for cobalt-60 content. Procedures for analysis will detect cobalt-60 if its concentration exceeds one three hundredths of the AEC limit (*1*). No cobalt-60 has been detected in any of the 3,460 water samples from all harbors monitored.

A radiological laboratory now part of the Environmental Protection Agency analyzed samples from harbors to identify radionuclides present in sediment. These analyses showed cobalt-60 was the predominant radionuclide added to sediment from Naval nuclear reactor operations. Therefore, Navy monitoring procedures require collecting 20 to 120 sediment samples in each harbor once each quarter year. Standard 6-inch square samplers modified to collect only the top one-half to one inch of sediment are used. The top layer was selected because it should be more mobile and more accessible to marine life than deeper layers. The samples are analyzed for gross gamma radioactivity and for cobalt-60. Results of the 3,146 sediment samples from harbors monitored by the Navy in the United States and possessions for 1972 are summarized in table 5.

Evaluation of the data summarized in table 5 shows that low-level cobalt-60 radioactivity in harbor bottom sediment is detected around a few piers at operating bases and shipyards where nuclear-powered ship maintenance and overhauls have been conducted over a period of several years. Cobalt-60 is not detectable above background levels in general harbor bottom areas away from these piers. Maximum total radioactivity observed in a U.S. harbor is less than 1 curie of cobalt-60. This radioactivity is small compared to background, since the quantity of naturally occurring radioactivity such as potassium-40, radium, uranium and thorium present in the sediment of a typical harbor amounts to hundreds of curies. Comparison to previous environmental monitoring data in references *8* through *14* shows that these environmental cobalt-60 levels have been steadily decreasing.

The first data column in table 5 includes all samples with less than 3 picocuries of cobalt-60 per gram of sediment. These low levels are difficult to measure because the levels of radioactivity in sediment from other sources are much higher. The value of 30 picocuries per gram was selected for the top of the second

Table 5. Summary of 1972 surveys for cobalt-60 in bottom sediment of U.S. harbors where U.S. Naval nuclear-powered ships have been regularly based, overhauled or built

Facility	Number of samples with cobalt-60			Total bottom area with cobalt-60 over 3 pCi/g [c] (km²)	Estimated total cobalt-60 in top layer of sediment [d] (Ci)
	<3 (pCi/g) [a]	3–30 (pCi/g)	>30–300 (pCi/g) [b]		
Portsmouth, N.H; Naval Shipyard	176	0	0	0	ND
Groton, New London, Conn; Electric Boat Division, State Pier and Submarine Base	461	40	2	0.1	0.02
Newport News, Va; Newport News Shipbuilding	152	0	0	0	ND
Norfolk, Va; Naval Shipyard and Base	344	0	0	0	ND
Charleston, S.C; Naval Shipyard and Bases	384	0	0	0	ND
Pascagoula, Miss; Ingalls Nuclear Division	216	0	0	0	ND
San Diego, Calif; Navy Piers at Ballast Point	160	0	0	0	ND
Long Beach, Calif; Naval Shipyard and Base	160	0	0	0	ND
Vallejo, Calif; Mare Island Naval Shipyard	397	0	0	0	ND
Bremerton, Wash; Puget Sound Naval Shipyard	156	0	0	0	ND
Pearl Harbor, Hawaii; Naval Shipyard and Sub Base	351	1	0	0.001	ND
Apra Harbor, Guam	104	0	0	0	ND
Port Canaveral, Fla	42	0	0	0	ND

[a] Minimum detectable radioactivity is approximately 1 pCi/g wet weight (picocurie per gram). Results in units of pCi/cm² range from two to four times the value of pCi/g.
[b] Maximum radioactivity in these samples was 59 pCi/g.
[c] One square kilometer is approximately equal to 0.4 square mile. Areas with cobalt-60 over 3 pCi/g were in immediate vicinity of piers used for berthing nuclear-powered ships.
[d] Where total cobalt-60 in the surface sediment layer is less than 0.01 curie, ND is reported. Samples more than 1 foot deep from several harbors show that total cobalt-60 present may be two to five times that measured in the surface layer.

range of data since it corresponds to the upper limit for exposure in references *1* and *3* even if consumed continuously by members of the general public. Although sediment cannot be consumed by humans, it might serve as a food source for marine life. Data on uptake of cobalt-60 from sediment by marine life obtained to date show that in the salt water harbor bottom environments, no significant buildup of cobalt-60 occurs in marine life. Such buildup is unlikely because the cobalt is in the form of insoluble metallic oxides. Therefore the third range of up to 300 picocuries per gram is selected as a range which would not cause members of the general public to receive radiation exposure approaching the values set in references *1-4*. Concentrations of cobalt-60 up to 300 picocuries per gram are so low that the AEC does not require those who might possess them to be licensed. If concentrations higher than 300 picocuries per gram were to persist over substantial areas of a harbor bottom, further monitoring would be performed to determine if any of this radioactivity were being taken up by marine life for eventual consumption in food. Because of the low concentrations noted in table 5, monitoring of radioactivity in marine life has not been necessary as part of the routine environmental monitoring programs in these harbors.

Estimates of the radiation exposure to members of the general public from radioactivity released into river and harbor waters and sediment and in air exhausted from facilities have been made as discussed in references *15* and *22*, by analyzing the pathways whereby radioactivity might be transmitted from the marine environment to man. These analyses considered direct exposure, such as to sediment along shorelines and by drinking harbor water, and indirect pathways such as consumption of bottom feeding fish or shellfish. These analyses showed that personnel exposure from this radioactivity would be far too low to measure and could only be estimated. Based on radioactivity released including the amounts and concentrations reported in table 2 of this report, the maximum radiation exposure in a year to any member of the general public would be less than 0.01 millirem. This is less than one ten thousandth of the average annual exposure of 125 millirem (*7*) to members of the general public from natural radioactivity or from exposure to medical diagnostic x rays. Thus the radioactivity released from the Naval nuclear propulsion program has not caused significant radiation exposure to the general public.

For comparison, references *23* and *24* contain evaluations by AEC laboratories of the effects on the environment from the accumulation near points of discharge of radionuclides from several nuclear reactors. These reports conclude for these other reactors that radioactivity levels much greater than shown in table 5 have caused no significant radiation exposure to the general public.

In all monitored harbors, shoreline areas uncovered at low tide are surveyed twice per year for radiation levels with sensitive radiation detectors to determine if any radioactivity from bottom sediment washed ashore. All results were the same as background radiation levels in these regions, approximately 0.01 millirem per hour. Thus there is no evidence in these ports that radioactivity from sediment is washing ashore.

Film badges are continuously posted at locations outside the boundaries of areas where radioactive work is performed. These films showed that radiation exposure to the general public outside these facilities was not above that received from natural background radiation levels.

Naval nuclear reactors and their support facilities are designed to ensure there are no significant discharges of radioactivity in airborne exhausts. Radiological controls are exercised in support facilities to preclude exposure of working personnel to airborne radioactivity exceeding limits such as specified in reference *1*. Further, all air exhausted from these facilities is passed through high efficiency particulate air filters and monitored during discharge. There were no discharges of airborne radioactivity above concentrations normally present in the atmosphere.

Conclusions

The total radioactivity discharged into all

ports and harbors from the U.S. Naval nuclear propulsion program was less than 0.002 curie in 1972.

No increase of radioactivity above normal background levels has been detected in harbor water where U.S. Naval nuclear-powered ships are based, overhauled, or constructed.

Liquid wastes from U.S. Naval nuclear-powered ships and support facilities have not caused a measurable increase in the general background radioactivity of the environment.

Low-level cobalt-60 radioactivity in harbor bottom sediment is detectable around a few piers at operating bases and shipyards where nuclear-powered ship maintenance and overhauls have been conducted over a period of several years. Cobalt-60 is not detectable above background levels in general harbor bottom areas away from these piers. Maximum total radioactivity observed in a U.S. harbor of less than one curie of cobalt-60 is small compared to the naturally occurring radioactivity. Comparison to previous environmental data summarized in references *8* through *14* show that these environmental cobalt-60 levels are continuing to decrease.

Procedures used by the Navy to control discharges of radioactivity from U.S. Naval nuclear-powered ships and their support facilities have been effective in protecting the environment and the health and safety of the general public.

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, May 1973

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 16 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radio-

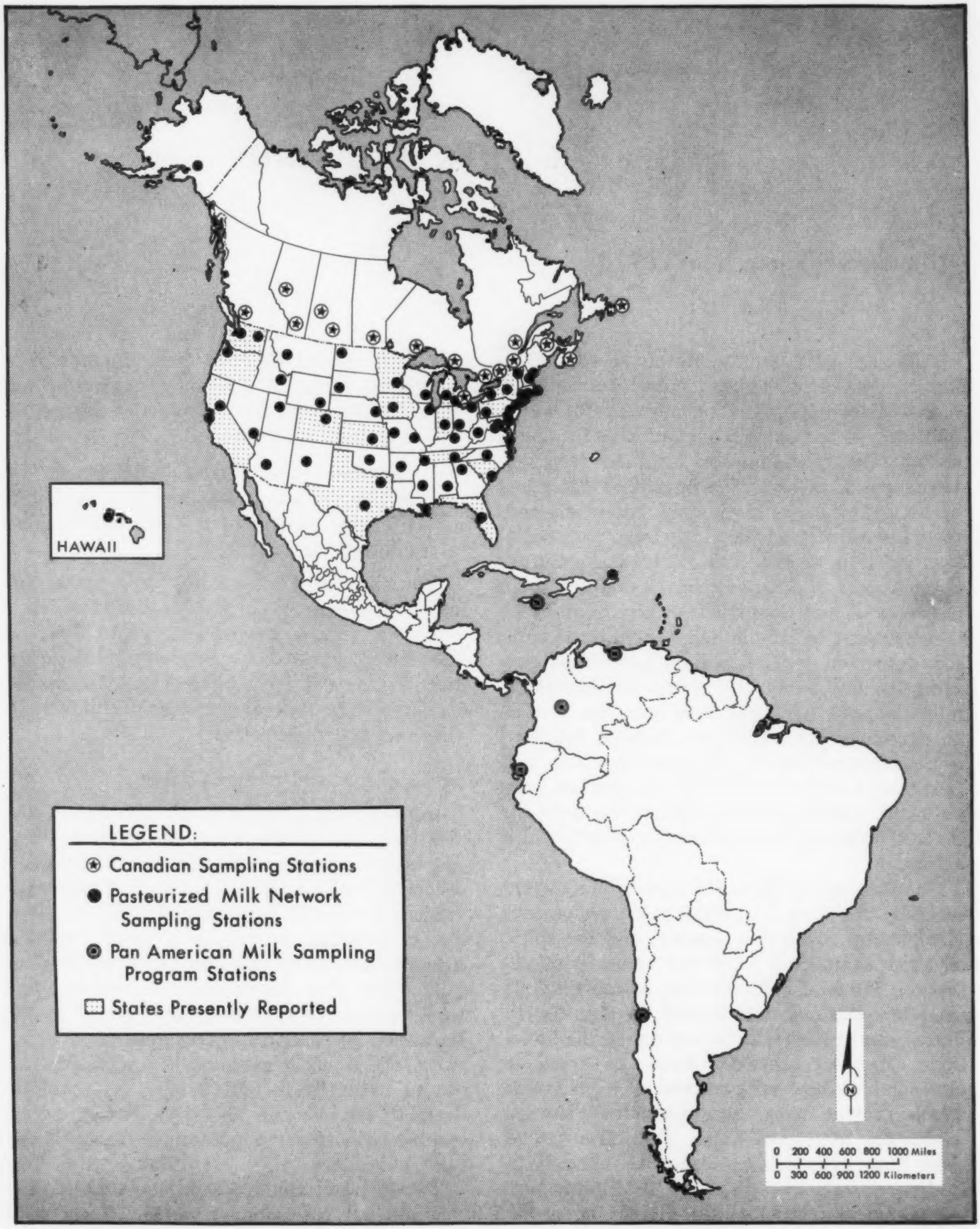

Figure 1. Milk sampling networks in the Western Hemisphere

strontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during June 1972 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 18 laboratories producing data for the network reports in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. The accuracy of the cesium-137 measurements continues to be excellent as in previous experiments. However, both the accuracy and precision need to be improved for iodine-131, strontium-89, and strontium-90 which could probably be accomplished through recalibration.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The fre-

Table 1. Distribution of mean results, quality control experiment

Radionuclide and known concentration		Number of laboratories in each category				Experimental 2σ error (pCi/liter)
		Acceptable[a]	Warning level[b]	Unacceptable[c]	Total	
Iodine-131:	(96 or 99 pCi/liter)	7 (58%)	1 (8%)	4 (33%)	12	6
	(438 or 484 pCi/liter)	11 (85%)	0	2 (15%)	13	25 or 28
Cesium-137:	(53 or 54 pCi/liter)	11 (92%)	0	1 (8%)	12	6
	(295 or 303 pCi/liter)	11 (85%)	2 (15%)	0	13	17
Strontium-89:	(29 or 30 pCi/liter)	9 (82%)	0	2 (18%)	11	6
	(197 or 201 pCi/liter)	3 (33%)	1 (11%)	5 (56%)	9	11 or 12
Strontium-90:	(32.1 or 32.4 pCi/liter)	4 (33%)	4 (33%)	4 (33%)	12	1.9
	(150.5 or 151.2 pCi/liter)	6 (55%)	0	5 (45%)	11	8.7

[a]Measured concentration equal to or within 2σ of the known concentration.
[b]Measured concentration outside 2σ and equal to or within 3σ of the known concentration
[c]Measured concentration outside 3σ of the known concentration.

quency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range has also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≧ 50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≧ 20 pCi/liter;
Iodine-131, Cesium-137, Barium-140	4–10% pCi/liter for levels <100 pCi/liter; 4–10% for levels ≧ 100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the February 1973 issue of *Radiation Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported in *Radiation Data and Reports.* The relationship between the PMN stations and the State stations is shown

Table 2. Concentrations of radionuclides in milk for May 1973 and 12-month period, June 1972 through May 1973

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:						
Ala:	Montgomery [c]	P	NA	5	0	4
Alaska:	Palmer [c]	P	2	4	0	2
Ariz:	Phoenix [c]	P	NA	0	0	0
Ark:	Little Rock [c]	P	9	9	0	3
Calif:	Sacramento [c]	P	NA	1	0	0
	San Francisco [c]	P	NA	0	0	0
	Del Norte	P	12	11	0	7
	Fresno	P	0	1	0	2
	Humboldt	P	3	3	0	2
	Los Angeles	P	0	1	0	2
	Mendocino	P	3	2	0	4
	Sacramento	P	2	2	0	3
	San Diego	P	0	1	0	3
	Santa Clara	P	0	2	0	2
	Shasta	P	2	2	0	5
	Sonoma	P	2	2	0	3
Colo:	Denver [c]	P	NA	3	0	0
	East	R	NS	NA	NS	7
	Northeast	R	NS	NA	NS	1
	Northwest	R	NA	NA	[d] 0 (4)	1
	South Central	R	NS	NS	NS	NS
	Southeast	R	NA	NA	[d] 0	0
	Southwest	R	NA	NA	[d] 0	2
	West	R	NA	NA	[d] 0	0
Conn:	Hartford [c]	R	NA	5	14	4
	Central	P	6	6	6	11
Del:	Wilmington [c]	P	NA	7	0	6
D.C:	Washington [c]	P	NA	5	0	3
Fla:	Tampa [c]	P	4	4	25	31
	Central	R	5	5	34	37
	North	R	4	6	17	14
	Northeast	R	8	5	29	31
	Southeast	R	3	5	63	47
	Tampa Bay area	P	5	5	24	32
	West	R	6	7	13	8
Ga:	Atlanta [c]	P	NA	8	6	8
Hawaii:	Honolulu [c]	P	0	1	0	0
Idaho:	Idaho Falls [c]	P	4	3	0	0
Ill:	Chicago [c]	P	5	5	0	3
Ind:	Indianapolis [c]	P	NA	4	0	1
	Central	P	6	7	0	8
	Northeast	P	4	5	15	8
	Northwest	P	6	7	10	10
	Southeast	P	6	7	0	7
	Southwest	P	7	7	0	9
Iowa:	Des Moines [c]	P	NA	5	0	0
	Iowa City	P	4	6	0	8
	Des Moines	P	5 (3)	5	0 (3)	2
	Little Cedar	P	NS	4	NS	2
	Spencer	P	NS	6	NS	3
Kans:	Wichita [c]	P	NA	5	0	0
	Coffeyville	P	7	8	0	9
	Dodge City	P	7	5	0	5
	Falls City, Nebr	R	7	3	0	7
	Hays	P	6	9	0	7
	Kansas City	P	NS		NS	
	Topeka	P	6	7	0	5
	Wichita	P	9	8	0	10
Ky:	Louisville [c]	P	NA	6	0	2
La:	New Orleans [c]	P	5	11	0	1
Maine:	Portland [c]	P	NA	5	18	19
Md:	Baltimore [c]	P	NA	6	0	4
Mass:	Boston [c]	P	7	6	36	15
Mich:	Detroit [c]	P	NA	6	12	4
	Grand Rapids [c]	P	NA	7	0	0
	Bay City	P	15	6	0 (2)	0
	Charlevoix	P	11 (2)	5	0 (4)	5
	Detroit	P	7	4	0	1
	Grand Rapids	P	5	4	0	3
	Lansing	P	12	5	0	3
	Marquette	P	7	5	7 (2)	11
	Monroe	P	NS	3	NS	2
	South Haven	P	9 (3)	6	0 (5)	5
Minn:	Minneapolis [c]	P	NA	7	0	8
	Bemidji	P	6	6	0	14
	Duluth	P	14	15	11	23
	Fergus Falls	P	6	7	0	0
	Little Falls	P	18	.18	0	17
	Mankato	P	5	5	0	0
	Marshall	P	3	4	0	0

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for May 1973 and 12-month period, June 1972 through May 1973—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:—continued						
Minn:	Minneapolis	P	5	9	16	12
	Rochester	P	4	7	11	0
Miss:	Jackson [e]	P	NA	8	0	7
Mo:	Kansas City [e]	P	NA	5	0	0
	St. Louis [e]	P	NA	6	0	1
Mont:	Helena [e]	P	NA	4	0	0
Nebr:	Omaha [e]	P	NA	4	0	0
Nev:	Las Vegas [e]	P	NA	1	0	0
N.H:	Manchester [e]	P	NA	6	0	13
N.J:	Trenton [e]	P	NA	6	0	5
N. Mex:	Albuquerque [e]	P	NA	0	0	0
N.Y:	Buffalo [e]	P	4	5	13	4
	New York City [e]	P	NA	8	0	3
	Syracuse [e]	P	NA	6	0	2
	Albany	P	5	4	0	0
	Buffalo	P	0	4	0	0
	Massena	P	7	6	0	0
	New York City	P	NA	6	0	0
	Syracuse	P	5	5	0	0
N.C:	Charlotte [e]	P	NA	7	0	5
N. Dak:	Minot [e]	P	NA	8	0	1
Ohio:	Cincinnati [e]	P	NA	5	12	2
	Cleveland [e]	P	NA	6	0	2
Okla:	Oklahoma City [e]	P	NA	4	0	0
Oreg:	Portland [e]	P	8	4	0	2
	Baker	P	NA		[d] 12	3
	Coos Bay	P	NA		[d] 0	7
	Eugene	P	NA		[d] 0	0
	Medford	P	NA		[d] 0	7
	Portland composite	P	NA		[d] 0	2
	Portland local	P	NA		[d] 0	1
	Redmond	P	NA		[d] 0	2
	Tillamook	R	NA		[d] 11	13
Pa:	Philadelphia [e]	P	NA	6	0	2
	Pittsburgh [e]	P	NA	8	0	5
	Dauphin	P	5	5	0	3
	Erie	P	7	7	0	3
	Philadelphia	P	0	5	0	5
	Pittsburgh	P	0	6	0	4
R.I:	Providence [e]	P	NA	5	11	9
S.C:	Charleston [e]	P	5	7	13	9
	Chapin	R	8	8	0	11
	Clemson	R	8	7	0	4
	Columbia	R	NS	7	NS	11
	Fairfield	R	8	7	0	13
	Hartsville-02	R	NS	6	NS	15
	Hartsville-03	R	NS	18	NS	18
	Lee County	R	NS	8	NS	18
	Oconee County	R	8	8	0	7
	Pickens	R	7	7	0	4
	Williston	R	NS	7	NS	15
	Winnsboro	R	7	8	20	24
S. Dak:	Rapid City [e]	P	NA	5	0	0
Tenn:	Chattanooga [e]	P	NA	8	0	5
	Memphis [e]	P	NA	6	0	1
	Chattanooga	P	7	8	0	7
	Clinton	R	5	7	12 (2)	8
	Fayetteville	R	6	8	0 (2)	7
	Kingston	R	5	7	0 (2)	2
	Knoxville	P	4	6	11	4
	Lawrenceburg	R	NS	4	NS	7
	Nashville	P	5	7	0	3
	Pulaski	R	6	6	0 (3)	4
	Sequoyah	R	NA	7	0	8
Tex:	Austin [e]	P	NA	2	0	0
	Dallas [e]	P	NA	5	0	0
	Amarillo	R	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	R	NA		NA	

See footnotes at end of table.

Table 2. Concentration of radionuclides in milk for May 1973 and 12-month period, June 1972 through May 1973—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:—continued						
Utah:	Salt Lake City [c]	P	3	3	0	2
Vt:	Burlington [c]	P	NA	5	11	7
Va:	Norfolk [c]	P	NA	6	0	3
Wash:	Seattle [c]	P	NA	4	0	1
	Spokane [c]	P	NA	4	0	1
	Benton County	R	0	1	0	0
	Franklin County	R	NS	1	NS	0
	Longview	R	6	4	0	2
	Sandpoint, Idaho	R	6	7	0	3
	Skagit County	R	4	6	0	8
W. Va:	Charleston [c]	P	NA	7	11	4
Wisc:	Milwaukee [c]	P	NA	5	0	3
Wyo:	Laramie [c]	P	NA	2	0	0
CANADA:						
Alberta:	Calgary	P	NA		11	11
	Edmonton	P	NA		13	16
British Columbia:						
	Vancouver	P	NA		10	17
Manitoba:						
	Winnipeg	P	NA		10	12
New Brunswick:						
	Moncton	P	NA		15	9
Newfoundland:						
	St. John's	P	NA		16	22
Nova Scotia:						
	Halifax	P	NA		13	12
Ontario:	Ottawa	P	NA		8	8
	Sault Ste. Marie	P	NA		16	18
	Thunder Bay	P	NA		8	15
	Toronto	P	NA		9	8
	Windsor	P	NA		10	7
Quebec:	Monteal	P	NA		9	8
	Quebec	P	NA		17	15
Saskatchewan:						
	Regina	P	NA		12	9
	Saskatoon	P	NA		9	10
CENTRAL AND SOUTH AMERICA:						
Canal Zone:						
	Cristobal [c]	P	NA	1	0	13
Chile:	Santiago	P	0	1	0	1
Colombia:	Bogota	P	NS	0	NS	0
Ecuador:	Guayaquil	P	0	0	0	0
Jamaica:	Mandeville	P	4	2	24	47
Puerto Rico:						
	San Juan [c]	P	NA	1	12	2
Venezuela:						
	Caracas	P	0	0	13	2
PMN network average [e]			5	5	3	4

[a] P, pasteurized milk.
R, raw milk.
[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.
[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.
[d] The practical reporting level for this network differs from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:
Cesium-137: Colorado—25 pCi/liter; Oregon—15 pCi/liter.
[e] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting

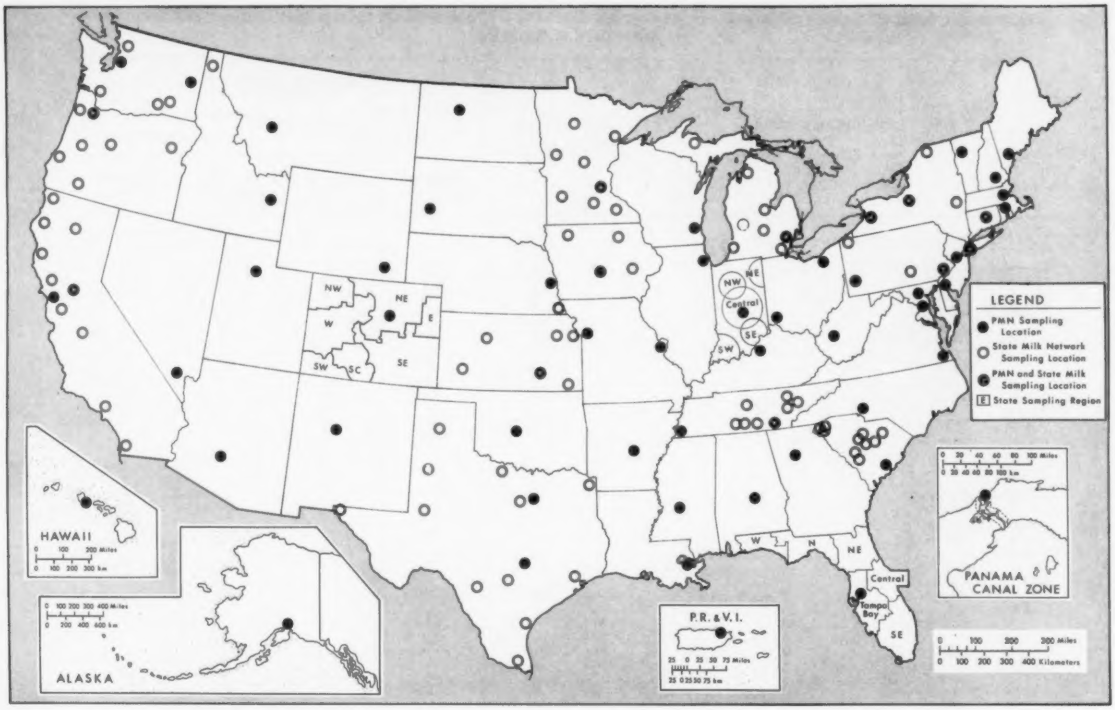

Figure 2. State and PMN milk sampling stations in the United States

levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for May 1973 and the 12-month period, June 1972 to May 1973. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for May 1973 were below the respective practical reporting levels. Barium-140 results for individual samples were all below the practical reporting level with the following exception: Kansas, Kansas City (State), 13 pCi/liter.

Strontium-90 monthly averages ranged from 0 to 18 pCi/liter in the United States for May 1973 and the highest 12-month average was 18 pCi/liter (Hartsville–03, S.C. and Little Falls, Minn.) representing 9.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 63 pCi/liter in the United States for May 1973, and the highest 12-month average was 47 pCi/liter (Southeast Florida) representing 1.3 percent of the value derived from the recommendations given in the Federal Radiation Council report.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Bureau of Radiological Health
Environmental Health and Consumer Protection Program
California Department of Public Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Division of Radiological Health
South Carolina State Board of Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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(*1*) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P STRAUB, F. J. WEBER and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1958. Amer J Pub Health 49:225 (February 1969).

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(*5*) BARATTA, E. J. and F. E. KNOWLES, JR. Interlaboratory Study of iodine-131, cesium-137, strontium-89, and strontium-90 measurements in milk, June 1972, Technical experiment 72 MKAQ–1. Analytical Quality Control Service, Office of Radiation Programs, EPA, Washington, D.C. 20460 (December 1972).

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Milk Surveillance Programs, March 1973

National Environmental Research Center—Las Vegas, Environmental Protection Agency

The Milk Surveillance Network,[1] operated by the National Environmental Research Center (NERC-LV) consists of 24 routine and two alternate sampling locations (figure 1) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing sponsored by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site (NTS).

[1] This network is operated under a Memorandum of Understanding (No. (AT-26-1)-539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

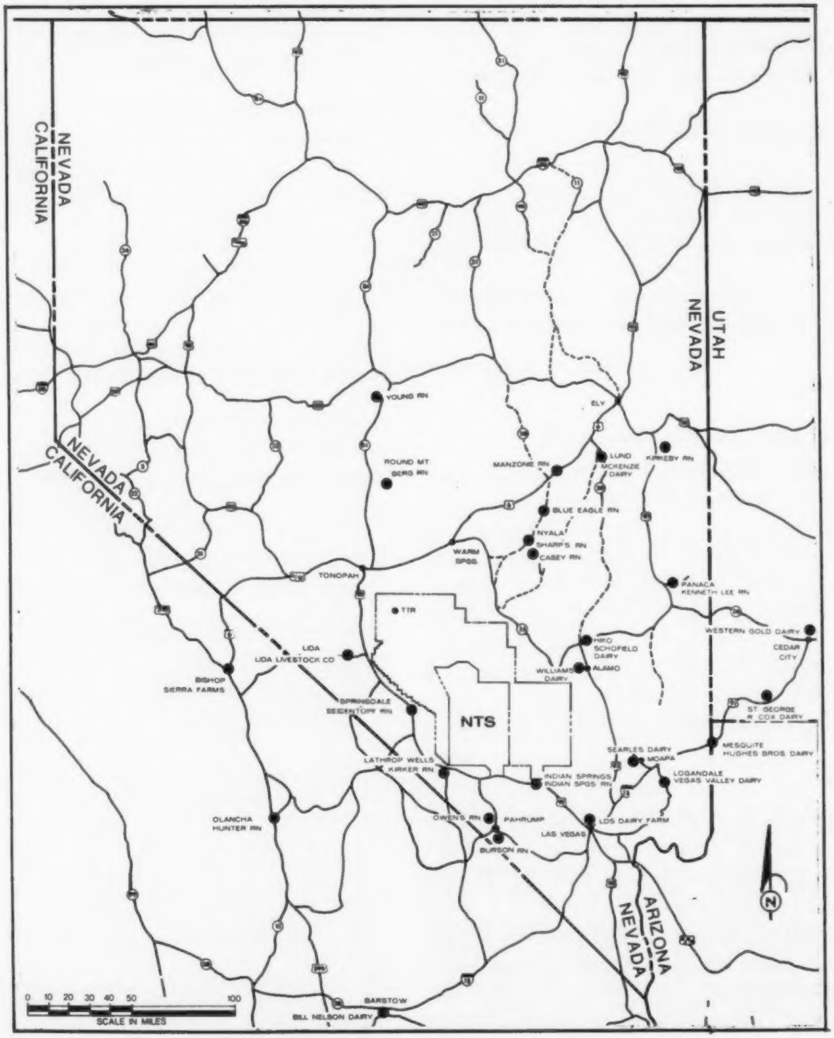

Figure 1. NERC-LV Milk Surveillance Network

Table 1. Milk surveillance results, March 1973

Location	Date collected (1973)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)			
			Cesium-137	Strontium-89	Strontium-90	Tritium
California:						
Bishop:						
Sierra Farms	3/1	11	<10	NA	NA	NA
Hinkley:						
Bill Nelson Dairy	3/1	12	<10	NA	NA	NA
Olancha:						
Hunter Ranch	NS					
Nevada:						
Alamo:						
Williams Dairy	3/1	12	<10	NA	NA	NA
Austin:						
Young's Ranch	3/1	13	<10	NA	NA	550±260
Currant:						
Blue Eagle Ranch	3/1	13	<10	NA	NA	NA
Manzonie Ranch	3/2	13	<10	NA	NA	NA
Hiko:						
Schofield Dairy	3/1	12	<10	NA	NA	<230
Indian Springs:						
Indian Springs Ranch	NS					
Las Vegas:						
LDS Dairy Farms	3/1	12	<10	NA	NA	330±240
Lathrop Wells:						
Kirker Ranch	3/1	13	<10	NA	NA	NA
Lida:						
Lida Livestock Company	NS					
Logandale:						
Vegas Valley Dairy	3/1	12	<10	NA	NA	NA
Lund:						
McKenzie Dairy	3/1	12	<10	NA	NA	<240
Mesquite:						
Hughes Brothers Dairy	3/1	12	<10	NA	NA	<230
Moapa:						
Searles Dairy	3/1	12	<10	NA	NA	NA
Nyala:						
Sharp's Ranch	3/1	13	[c] <100	NA	NA	<230
Pahrump:						
Owens Ranch	3/1	13	<10	NA	NA	NA
Panaca:						
Kenneth Lee Ranch	3/1	13	<10	NA	NA	NA
Round Mountain:						
Berg Ranch	3/1	13	<10	NA	NA	NA
Shoshone:						
Kirkeby Ranch	3/1	13	<10	NA	NA	NA
Springdale:						
Seidentopf Ranch	3/1	13	<10	NA	NA	NA
Utah:						
Cedar City:						
Western Gold Dairy	3/1	12	<10	NA	NA	NA
St. George:						
R. Cox Dairy	3/1	12	<10	NA	NA	NA

[a] 11—Pasteurized milk.
12—Raw milk from Grade A producer(s).
13—Raw milk from family cow(s).
[b] Two-sigma counting error provided when available.
[c] Small sample size increased minimum detectable activity.
NA, not analyzed.
NS, no sample.

In the event of a release of radioactivity from the NTS, special sampling within the affected area is conducted to determine radionuclide concentrations. Additional milk sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and analytical procedures was included with the milk results reported in the July 1973 issue of *Radiation Data and Reports*.

Results

The analytical results of all milk samples collected in March 1973 by NERC-LV surveillance programs are listed in table 1. With the exception of cesium-137 at levels near the min-

imum detectable activity (MDA) of 10 pCi/liter, no gamma-emitting fission products were identified by gamma spectrometry in any of the samples collected in March 1973. Levels of tritium near the MDA for this radionuclide (200 pCi/liter) were also measured by liquid scintillation. The highest concentration of tritium during March was 550 ± 260 pCi/liter.

Food and Diet Surveillance

Efforts are being made by various Federal and States agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intake of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January–June 1971	December 1972
Carbon-14 in Total Diet and Milk	July–December 1971	May 1972
Institutional Diet Samples	July–September 1972	August 1973
Radiostrontium in Milk	January–December 1971	November 1972
Strontium-90 in Tri-City Diets	January–December 1971	December 1972

Radionuclides in Institutional Diet Samples, October–December 1972 and 1972 Annual Summary

Environmental Protection Agency
Food and Drug Administration

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. Recognizing that the diet is a potentially significant contribution to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. The program is now administered by the Office of Radiation Programs, Environmental Protection Agency with the assistance of the Office of Food Sanitation, Food and Drug Administration, Department of Health, Education and Welfare (*1*).

This program estimates the dietary intake of radionuclides in a selected population group, ranging from children to young adults of school age. At present 26 institutions—distributed geographically as shown in figure 1—are being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, but teenage boys consumed 20 percent more food per day (*1,2*). Extrapolating this information, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intake of children.

The sampling procedure is generally the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus between-meal snacks), obtained by duplicating the food intake of a different

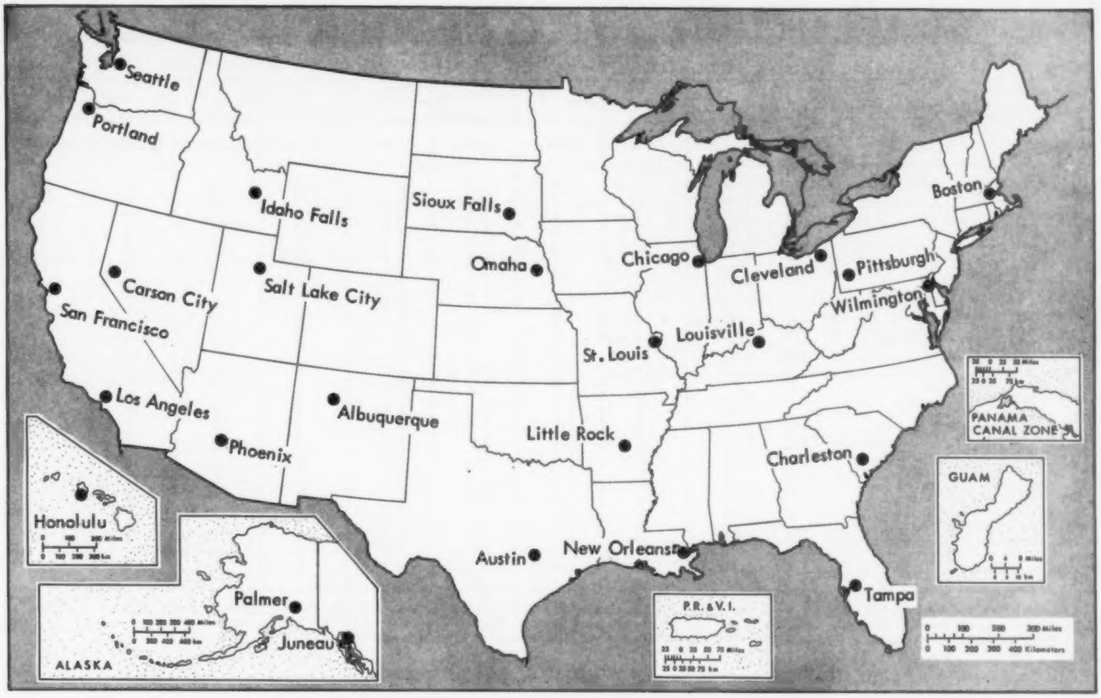

Figure 1. Institutional diet sampling locations as of December 1972

Table 1. Concentration and intake of stable elements and radionuclides in institutional total diets of children, October–December 1972

Location of Institution		Month [a] (1972)	Total weight (kg/day)	Calcium (g/kg)	Calcium (g/day)	Potassium (g/kg)	Potassium (g/day)	Strontium-90 (pCi/kg)	Strontium-90 (pCi/day)	Cesium-137 (pCi/kg)	Cesium-137 (pCi/day)
Alaska:	Juneau	Oct	2.26	0.7	1.6	1.2	2.7	5	11	0	0
	Palmer	Dec [b]	1.21	.4	.5	1.4	1.7	3	3	0	0
Ariz:	Phoenix	Oct	1.89	.5	.9	1.5	2.9	2	4	0	0
Ark:	Little Rock	Oct	1.47	.4	.6	1.7	2.4	3	5	0	0
Calif:	Los Angeles		NS								
	San Francisco	Oct [b]	1.53	.6	.9	2.0	3.1	2	4	0	0
Del:	Wilmington	Nov	1.21	.8	.9	1.3	1.5	6	7	0	0
Fla:	Tampa	Nov	1.85	.6	1.2	1.4	2.7	6	11	15	28
Hawaii:	Honolulu	Oct [b]	2.00	.5	1.1	1.8	3.7	3	5	0	0
Idaho	Idaho Falls	Oct [b]	1.24	.3	.4	1.8	2.2	4	5	0	0
Ill:	Chicago		NS								
Ky:	Louisville	Nov	2.36	.8	1.9	1.5	3.5	5	11	0	0
La:	New Orleans	Oct [b]	1.65	.6	1.0	2.1	3.5	4	7	13	21
Mass:	Boston	Oct [b]	2.32	.6	1.5	1.4	3.2	6	14	11	26
Mo:	St. Louis	Oct [b]	1.09	.7	.7	1.6	1.8	5	6	0	0
Nebr:	Omaha	Oct [b]	2.50	.8	1.9	1.6	4.0	5	13	0	0
Nev:	Carson City	Oct	.90	.6	1.1	1.6	3.1	4	8	0	0
N. Mex:	Albuquerque	Dec [b]	1.81	.6	1.2	1.8	3.2	3	6	0	0
Ohio:	Cleveland	Oct [b]	.95	.5	.5	1.4	1.4	5	5	0	0
Oreg:	Portland	Oct [b]	2.21	.5	1.1	1.6	3.6	3	7	0	0
Pa:	Pittsburgh	Oct	2.10	.5	1.0	1.1	2.4	4	9	0	0
S.C:	Charleston	Oct [b]	1.31	.6	.8	1.5	2.0	6	7	19	25
S. Dak:	Sioux Falls	Oct [b]	1.02	.5	.5	1.3	1.4	2	2	0	0
Tex:	Austin	Oct [b]	1.52	.7	1.0	1.5	2.3	0	0	0	0
Utah:	Salt Lake City	Oct [b]	2.08	.5	1.0	1.3	2.6	2	5	0	0
Wash:	Seattle	Oct [b]	1.92	.6	1.1	1.6	3.1	3	5	0	0
Institutional average			1.72	0.6	1.0	1.5	2.7	4	7	2	4

[a] Quarterly sample usually collected the first month of the quarter.
[b] Food samples were collected from two or more children who were not between the ages of 9 and 12.
Note: Iodine-131, barium-140, and strontium-89 were not detected at any station during this period.
NS, no sample.

Table 2. 1972 annual average concentration and intake of stable elements and radionuclides in institutional total diets of children[a]

Location of Institution		Total weight (kg/day)	Calcium		Potassium		Strontium-90		Cesium-137	
			(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska:	Juneau [b]	2.06	0.7	1.4	1.5	3.1	4	8	21	43
	Palmer [b]	1.66	.5	.8	1.6	2.6	7	12	19	31
Ariz:	Phoenix	1.67	.5	.9	1.9	3.1	3	6	0	0
Ark:	Little Rock	1.51	6	.8	1.7	2.6	7	11	4	5
Calif:	Los Angeles [b]	1.41	.3	.4	1.3	1.9	2	3	0	0
	San Francisco [b]	1.77	.7	1.3	1.8	3.3	3	6	0	0
Del:	Wilmington [b]	1.06	.7	.8	1.3	1.4	5	6	6	6
Fla:	Tampa	1.97	.6	1.1	1.4	2.8	5	10	19	37
Hawaii:	Honolulu [b]	2.19	.5	1.1	1.7	3.7	3	7	0	0
Idaho:	Idaho Falls [b]	1.38	.6	.8	1.6	2.3	7	10	8	11
Ill:	Chicago [b]	1.13	.6	.6	1.6	1.8	5	6	19	21
Ky:	Louisville [b]	2.17	.8	1.6	1.5	3.3	6	13	3	7
La:	New Orleans [b]	1.42	.6	.8	1.9	2.7	6	9	10	15
Mass:	Boston [b]	2.46	.6	1.5	1.3	3.2	5	12	7	17
Mo:	St. Louis [b]	1.04	.7	.8	1.9	2.0	5	5	5	5
Nebr:	Omaha [b]	2.15	.7	1.6	1.6	3.4	5	10	0	0
Nev:	Carson City	1.46	.7	1.1	1.6	2.4	4	6	0	0
N. Mex:	Albuquerque [b]	1.86	.6	1.1	1.8	3.3	4	7	0	0
Ohio:	Cleveland [b]	1.12	.6	.7	1.5	1.7	6	7	9	10
Oreg:	Portland [b]	2.04	.5	1.0	1.7	3.5	4	9	8	15
Pa:	Pittsburgh [b]	2.64	.5	1.2	1.3	3.3	5	13	0	0
S.C:	Charleston [b]	1.61	.6	1.0	1.4	2.3	6	10	11	18
S. Dak:	Sioux Falls [b]	1.13	.6	.7	1.4	1.6	6	6	0	0
Tex:	Austin [b]	1.38	.7	1.0	1.7	2.4	4	5	0	0
Utah:	Salt Lake City [b]	2.19	.5	1.1	1.5	3.2	3	6	3	7
Wash:	Seattle [b]	1.88	.5	1.0	1.7	3.2	3	5	3	5
Institutional average		1.71	0.6	1.0	1.6	2.7	5	8	8	10

[a] Iodine-131 and barium-140 were not detected at any station during this period. Strontium-89 was detected as follows: Omaha, Nebr.—7 pCi/kg or 13 pCi/day in April; Juneau, Alaska—6 pCi/kg or 9 pCi/day in July; and Seattle, Wash.—7 pCi/kg or 12 pCi/day in July.
[b] Food samples were collected from two or more children who were not between the ages of 9 and 12.

individual daily. Drinking water—which is not included—is also sampled periodically. Each daily sample is kept frozen until the end of the collection period. It is then packed in dry ice and shipped by air to either the National Environmental Research Center, Las Vegas, Nev. or the Eastern Environmental Radiation Facility, Montgomery, Ala. A detailed description of sampling and analytical procedures has already been presented in *Radiological Health Data and Reports* (*3*).

Results

Table 1 shows the analytical results for institutional diet samples collected from all stations during October–December 1972. The stable elements calcium and potassium are reported in g/kg of diet. Where applicable, radionuclide concentrations of these samples reported in pCi/kg of diet are corrected for radioactive decay to the midpoint of the sample collection period. Dietary intakes in g/day or pCi/day were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.72 kg/day compared to the network average of 1.84 kg/day observed from 1961 through 1972.

Strontium-90 dietary intake averaged 7 pCi/day during this period. Cesium-137 intake averaged 4 pCi/day. These results fall within Range I as defined by the former Federal Radiation Council (*4*). Strontium-89, barium-140, and iodine-131 concentrations were below detectable levels.

All concentrations less than or equal to the appropriate minimum detectable level have been reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the two standard-deviation analytical error. Accordingly, the minimum detectable limits are strontium-89, 5 pCi/kg; strontium-90, 2 pCi/kg; iodine-131, 10 pCi/kg; barium-140, 10 pCi/kg; cesium-137, 10 pCi/kg.

Annual average radionuclide concentrations and intakes are presented in table 2 for all stations. During 1972, the annual average intake

for these institutions was 1.71 kg/day as compared to the network average of 1.84 kg/day observed from 1961–1972. The average levels of radionuclide concentrations are similar to those of previous years.

Recent coverage in *Radiation Data and Reports:*

Period	Issue
October–December 1971	June 1972
January–March 1972	June 1973
April–June 1972	July 1973
July–September 1972	August 1973

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(*1*) ANDERSON, E. C., D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(*2*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1965. Radiol Health Data 6:548–554 (October 1965).

(*3*) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1968. Radiol Health Data Rep 9:557–560 (October 1968).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	January–December 1970	June 1972
Colorado River Basin	1968	March 1972
Community Water Supply Study	1968	September 1972
Florida	1969	January 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	January–December 1971	February 1973
Michigan	January–June 1970	November 1971
Minnesota	July 1970–June 1971	November 1972
New York	July–December 1971	August 1973
North Carolina	1968–1970	September 1972
Radiostrontium in Tap Water, *HASL*	July–December 1971	November 1972
Surface Waters	January 1969–December 1970	July 1973
Tritium Surveillance System	January–March 1973	July 1973
Washington	July 1970–June 1971	August 1973
Water Surveillance Programs, *NERC-LV*	February 1973	August 1973

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(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States December 1972

Office of Radiation Programs
U.S. Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was initiated in 1967 as part of the Water Pollution Surveillance System (formerly National Water Quality Network) of the U.S. Public Health Service. Currently, the program is operated by the U.S. Environmental Protection Agency, Office of Radiation Programs. Regional offices of the Environmental Protection Agency are responsible for the collection and retrieval system. Radioactivity analyses were performed at the Eastern Environmental Radiation Facility, Montgomery, Ala.

Table 1 presents the gross alpha and beta radioactivity results for samples collected from rivers during December 1972. The analytical procedures used for determining gross alpha and beta radioactivity are described in the 13th Edition of *Standard Methods for the Examination of Water and Wastewater* (*1*). Results are collected for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards, Handbook 86 (*2*) and is calculated to be $<$ 1 pCi/liter for gross alpha and gross beta radioactivity measurements.

Due to the low levels of radioactivity in the rivers of the United States, this network was discontinued effective December 31, 1972.

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(*1*) AMERICAN PUBLIC HEALTH ASSOCIATION: AMERICAN WATER WORKS ASSOCIATION AND WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater, 13th Edition, New York, N.Y. (1971).

(*2*) U.S. DEPARTMENT OF COMMERCE. Radioactivity, Recommendations of the International Commission on Radiological Units and Measurements (1962), NBS Handbook 86 (November 29, 1963).

Table 1. Gross radioactivity in U.S. surface waters, December 1972

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Roanoke River:					
John Kerr Dam, Va	4	<1	<1	<1	3
		<1	<1	<1	2
		<1	<1	<1	3
		<1	<1	<1	2
St. Lawrence River:					
Massena, N.Y	3	<1	<1	<1	4
		<1	<1	<1	3
		<1	<1	<1	2
St. Clair River:					
Port Huron, Mich	1	<1	<1	<1	3
St. Mary's River:					
Sault Ste. Marie, Mich	1	<1	<1	<1	<1

Water Surveillance Programs, March 1973

National Environmental Research Center—Las Vegas, Environmental Protection Agency

The Water Surveillance Network,[1] operated by the National Environmental Research Center—Las Vegas (NERC-LV), consists of 61 sampling locations (figures 1 and 2) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing programs conducted by the U.S. Atomic Energy Commission (AEC) at the Nevada Test Site.

[1] This network is operated under a Memorandum of Understanding (No. (AT-26-1)-539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

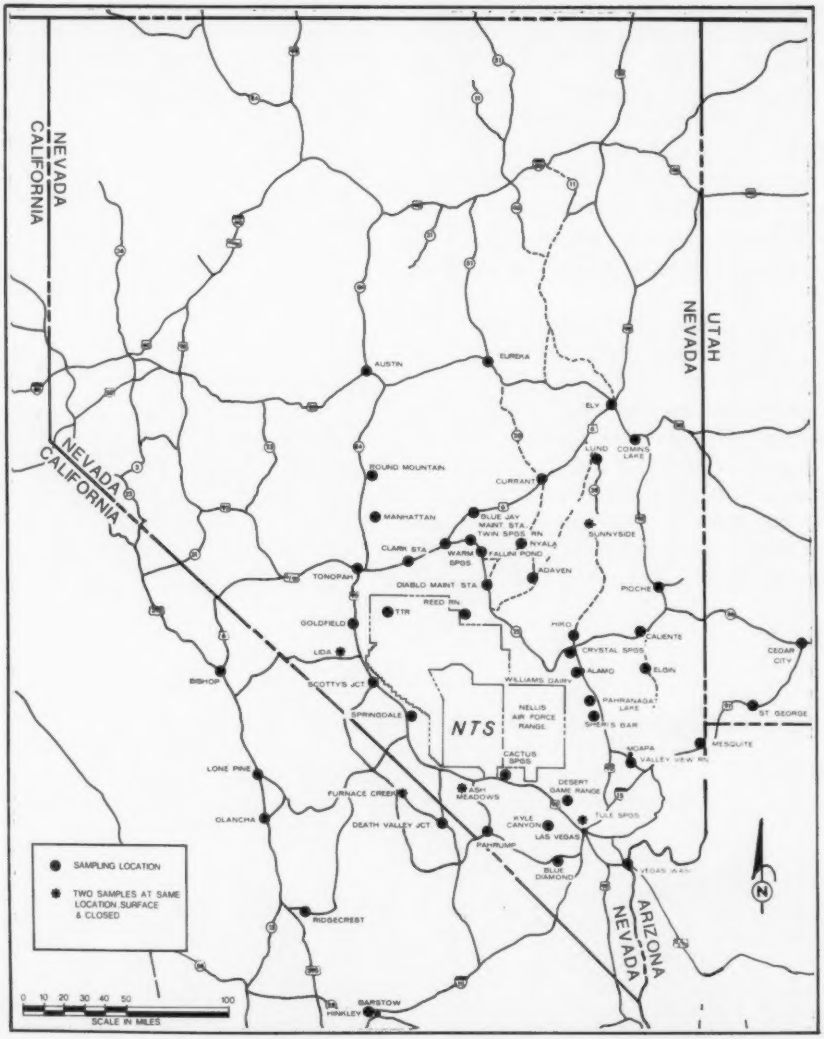

Figure 1. NERC-LV Water Surveillance Network

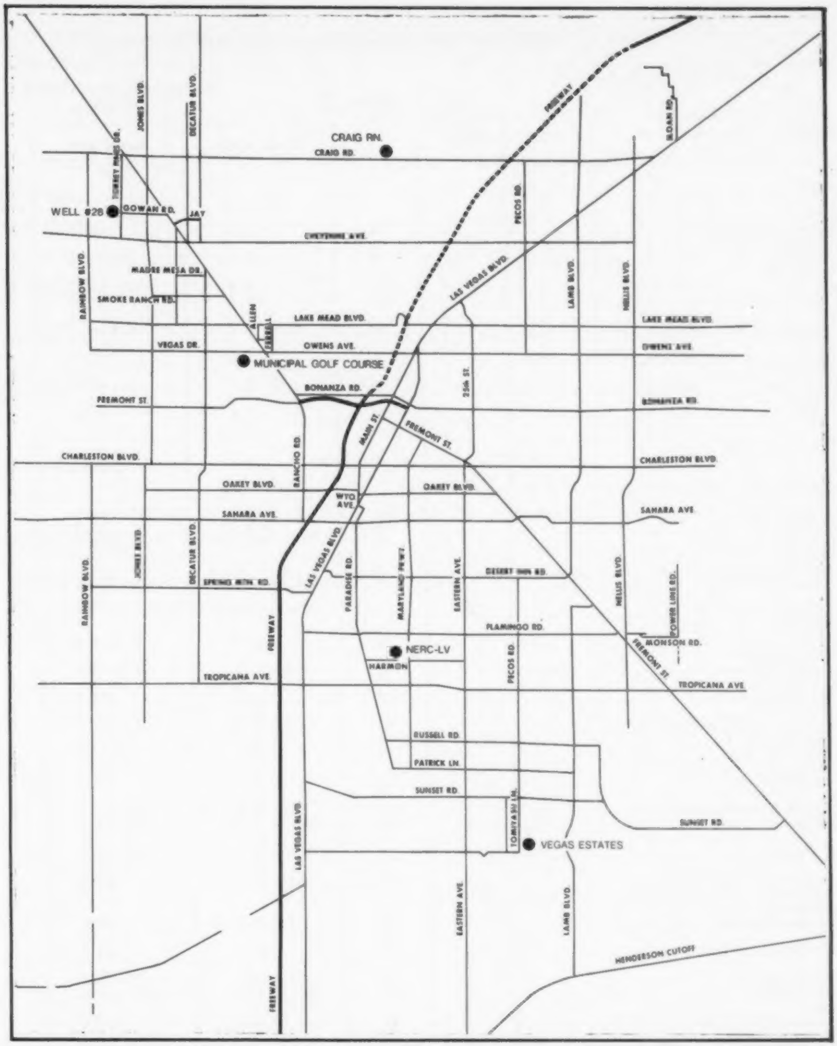

Figure 2. NERC-LV Water Surveillance Network—Las Vegas Valley

In the event of a release of radioactivity from the NTS, special sampling within the affected area is conducted to determine radionuclide concentrations. Additional water sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and routine analytical procedures was included with the water results reported in the July 1973 issue of *Radiation Data and Reports*.

Results

The routine analytical results of all water samples collected in March 1973 by the NERC-LV water surveillance network are listed in table 1. No gamma-emitting fission products were identified by gamma spectrometry in any of the samples collected in March. The analytical results for calendar year 1973 samples selected for special analyses will be reported at a later date.

Table 1. NERC-LV water surveillance results, March 1973

Location	Date collected (March 1973)	Sample type [a]	Radioactivity concentration [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
California:					
Bishop:					
Fish and Game Office	1	23	<1.6	<3.3	NA
Death Valley Junction:					
Lila's Cafe	1	23	<5.1	9.3±3.9	<240
Furnace Creek:					
Pond	1	21	<3.6	13 ±4.0	NA
Visitors Center	1	27	<4.0	8.2±3.8	NA
Hinkley:					
Bill Nelson Dairy	1	23	8.1± 5.4	4.0±3.7	NA
Lone Pine:					
Forest Service Ranger Station	1	23	<1.9	<3.3	NA
Olancha:					
Haiwee Reservoir	1	21	4.7± 3.7	4.4±3.4	NA
Ridgecrest:					
City Hall	1	23	<2.3	<3.4	NA
Nevada:					
Adaven:					
Canfield Ranch	NS				
Alamo:					
Pahranagat Lake	1	21	13 ± 6.4	13 ±4.2	NA
Sheri's Bar	1	23	<3.4	<3.4	NA
Williams Dairy	1	23	<3.1	9.0±3.8	NA
Ash Meadows:					
Ash Meadows Lodge	1	23	1.4± .95	14 ±4.0	<240
Ash Meadows Pond	1	21	24 ±10	16 ±4.5	NA
Austin:					
Nevada National Bank	NS				
Blue Diamond:					
Post Office	1	23	<2.8	9.6±3.9	<240
Blue Jay Highway:					
Maintenance Station	1	23	4.2± 3.4	5.3±3.7	NA
Cactus Springs:					
Mobil Service Station	1	27	<2.3	<3.5	<240
Caliente:					
Agricultural Extension Station	1	23	7.6± 4.4	6.1±3.7	NA
Clark Station:					
Five Mile Ranch	1	27	<2.5	<3.6	NA
Currant:					
Currant Ranch Cafe	1	27	11 ± 5.4	<3.6	NA
Diablo:					
Highway Maintenance Station	1	23	4.0± 3.5	5.6±3.7	NA
Reed Ranch	2	21	23 ± 7.9	3.7±3.4	NA
Elgin:					
Water tower	1	23	7.7± 5.1	6.7±3.6	NA
Ely:					
Chevron Service Station	1	24	3.2± 2.6	<3.5	NA
Comins Lake	NS				
Eureka Highway:					
Maintenance Station	1	24	4.7± 3.3	<3.6	NA
Goldfield:					
Chevron Service Station	1	23	<3.1	<3.4	NA
Hiko:					
Crystal Springs	1	27	4.7± 3.8	7.0±3.6	NA
Schofield Dairy	1	23	18 ± 7.0	22 ±4.4	NA
Las Vegas:					
Craig Ranch Golf Course	1	23	<2.9	<3.5	<240
Desert Game Range	1	23	4.1± 3.3	6.3±3.7	<240
Lab II, NERC-LV	1	24	<5.0	6.6±3.9	950±250
Lake Mead Vegas Wash	1	21	<3.7	5.0±3.8	900±250
LV Water District Well 28	1	23	<2.3	<3.5	<250
Municipal Golf Course	1	23	<2.6	<3.5	<250
Tule Springs	1	23	3.3± 3.0	<3.5	<240
Tule Springs Pond	1	21	5.0± 3.3	<3.5	NA
Vegas Estates	1	23	<5.4	12 ±4.2	<250
Lida:					
Lida Livestock Company	1	27	4.1± 3.9	<3.6	NA
Pond at storage tank	1	21	<3.8	<3.4	NA
Lund:					
Gardiner Grocery	1	23	<2.5	<3.6	NA
Manhattan:					
Country Store	1	23	12 ± 6.7	<3.5	NA
Mesquite:					
Hughes Brothers Dairy	1	23	<4.4	5.2±3.6	NA
Moapa:					
Pedersen Valley View Ranch	1	27	7.8± 5.5	14 ±4.1	NA
Mt. Charleston:					
Kyle Canyon Fire Station	1	27	<2.2	<3.5	<250
Nyala:					
Sharp's Ranch	1	23	<2.2	<3.6	NA
Pahrump:					
Texaco Service Station	1	23	<2.3	<3.6	NA
Pioche:					
County Courthouse	1	24	<2.3	6.7±3.5	NA

See footnotes at end of table.

Table 1. NERC-LV water surveillance results, March 1973—continued

Location	Date collected (March 1973)	Sample type [a]	Radioactivity concentration [b] (pCi/liter)		
			Gross alpha	Gross beta	Tritium
Round Mountain:					
Mobil Service Station	1	27	<2.0	<3.5	NA
Scotty's Junction:					
Chevron Service Station	1	23	6.8± 5.9	10 ±3.9	<240
Springdale:					
Pond	1	21	12 ± 6.7	5.9±3.9	NA
Sunnyside:					
Adam McGill Reservoir	NS				
Wildlife Mgt. Headquarters	1	27	<1.8	<3.5	NA
Tonopah:					
Jerry's Chevron Station	1	23	<3.6	5.0±3.5	NA
Tonopah Test Range CP-1	1	23	4.9± 4.2	6.4±3.6	NA
Warm Springs:					
Fallini's Pond	1	21	28 ±10	34 ±5.3	NA
Service Station and Cafe	2	27	24 ± 9.7	26 ±4.8	NA
Twin Springs Ranch	1	23	<3.5	11 ±3.9	NA
Utah:					
Cedar City:					
M. D. Baldwin Residence	2	24	<2.1	<3.5	NA
St. George:					
R. Cox Dairy	1	24	2.9± 2.2	<3.3	NA

[a] 21—pond, lake, reservoir, stock tank, or stock pond.
22—stream, river, or creek.
23—well.
24—multiple supply-mixed water sample consisting of mixed or multiple sources of water, such as well and spring.
27—spring.

[b] Two-sigma counting error provided when available.
NA, not analyzed.
NS, no sample.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports*.

Network	Period	Issue
Mexican air monitoring	May–August 1972	January 1973
Plutonium in airborne particulates	October–December 1972	June 1973
Surface air sampling program, 80th Meridian Network, *HASL*	1970	May 1973

1. Radiation Alert Network
May 1973

Quality Assurance and Environmental Monitoring Laboratory
National Environmental Research Center—Research Triangle Park
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 68 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Quality Assurance and Environmental Monitoring Laboratory, NERC-RTP, EPA, Research Triangle Park, N.C. 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during May 1973.

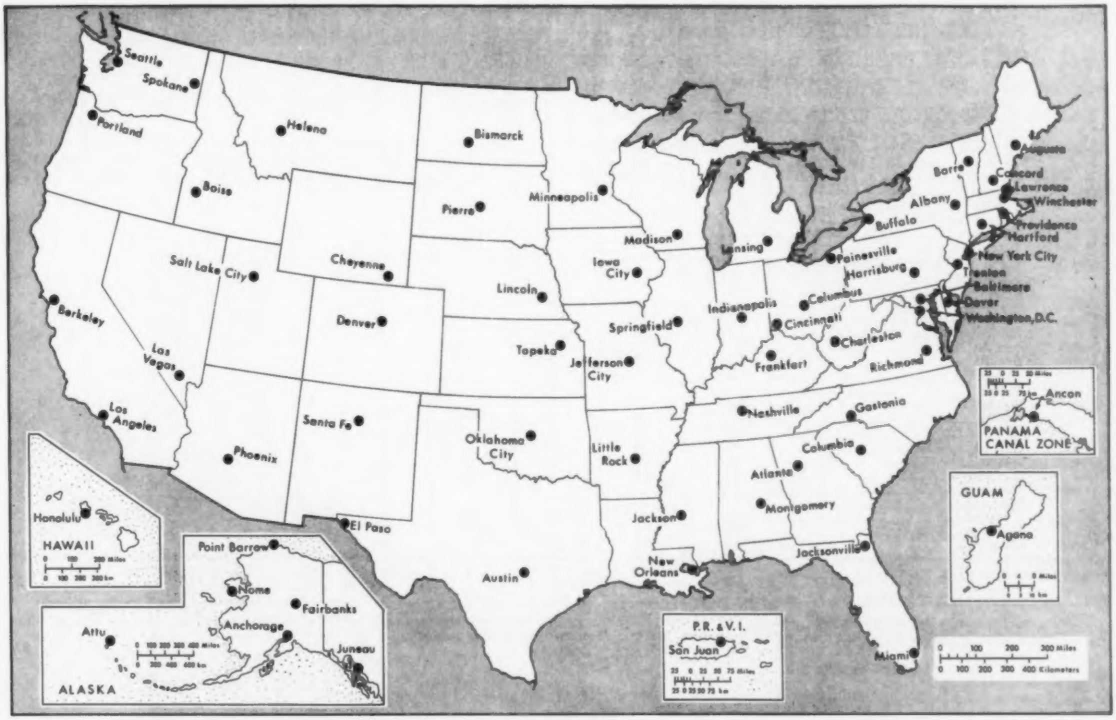

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, May 1973

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Precipitation				
						Number of samples	Total depth (mm)	Field estimation of deposition		
			Maximum	Minimum	Average[a]			Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	20	2	0	1	2	57	2	57	1
Alaska:	Anchorage	0				0		(b)		
	Attu Island	0				0				
	Fairbanks	0				0				
	Juneau	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	0				0				
Ark:	Little Rock	0				0				
Calif:	Berkeley	0				0				
	Los Angeles	0				0				
C.Z:	Ancon	18	0	0	0	0				
Colo:	Denver	23	5	0	1	6	138	(b)		
Conn:	Hartford	21	1	0	0	11	136	11	136	0
Del:	Dover	22	1	0	0	0				
D.C:	Washington	18	1	0	0	0				
Fla:	Jacksonville	21	1	0	0	6	149	6	149	0
	Miami	4	0	0	0	1	5	1	5	0
Ga:	Atlanta	0				0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	0				0		(b)		
Idaho:	Boise	21	2	0	1	1	25	1	25	0
Ill:	Springfield	4	2	0	1	0				
Ind:	Indianapolis	20	2	0	1	0				
Iowa:	Iowa City	22	3	0	1	8	200	8	200	12
Kans:	Topeka	22	8	0	1	6	118	6	118	2
Ky:	Frankfort	18	2	0	0	0				
La:	New Orleans	20	0	0	0	5	167			
Maine:	Augusta	21	1	0	0	8	120	8	120	0
Md:	Baltimore	20	1	0	0	6	55	6	55	0
Mass:	Lawrence	20	1	0	0	9	118	9	118	0
	Winchester	18	1	0	0	7	71	7	71	0
Mich:	Lansing	22	1	0	0	11	94	11	94	9
Minn:	Minneapolis	17	2	0	1	7	130	7	130	21
Miss:	Jackson	1	0	0	0	0				
Mo:	Jefferson City	22	2	0	1	8	129	8	129	0
Mont:	Helena	13	2	0	1	0				
Nebr:	Lincoln	20	9	0	3	3	43	3	43	6
Nev:	Las Vegas	0				0				
N.H:	Concord	0				0				
N.J:	Trenton	21	1	0	0	12	110	12	110	3
N. Mex:	Santa Fe	17	3	0	1	1	5	1	5	0
N.Y:	Albany	22	2	0	1	0				
	Buffalo	21	1	0	0	0				
	New York City	0				0				
N.C:	Gastonia	22	9	0	2	2	38	(b)		
N. Dak:	Bismarck	21	9	0	2	3	74	3	74	1
Ohio:	Cincinnati	0				0				
	Columbus	0				0				
	Painesville	22	1	0	0	14	121	14	121	33
Okla:	Oklahoma City	4	2	0	1	0				
Oreg:	Portland	0				0				
Pa:	Harrisburg	19	1	9	0	0				
P.R:	San Juan	0				0				
R.I:	Providence	18	1	0	0	0				
S.C:	Columbia	10	1	0	0	4	61	4	61	0
S. Dak:	Pierre	0				0				
Tenn:	Nashville	22	2	0	1	7	105	7	105	1
Tex:	Austin	21	6	1	3	38		(b)		
	El Paso	17	4	0	1	0				
Utah:	Salt Lake City	29	2	0	1	4	51	4	51	2
Vt:	Barre	19	2	0	1	6	134	6	134	10
Va:	Richmond	17	1	0	0	3	21	3	21	1
Wash:	Seattle	0				0				
	Spokane	0				0		(b)		
W. Va:	Charleston	22	4	0	1	11	134	11	134	9
Wisc:	Madison	21	1	0	0	11	161	11	161	8
Wyo:	Cheyenne	16	5	0	2	0				
Network summary		829	9	0	1	186	108	7	93	5

[a]The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b]This station is part of the tritium surveillance system. No gross beta measurements are done.

2. Air Surveillance Network, May 1973

National Environmental Research Center—Las Vegas[1] Environmental Protection Agency

The Air Surveillance Network[2] (ASN), operated by the National Environmental Research Center—Las Vegas (NERC-LV), consists of 49 active and 73 standby sampling stations located in 21 western States (figures 2 and 3). The network is operated in support of nuclear testing conducted by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), and at any other designated testing sites.

The stations are operated by State health department personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being exchanged over periods generally ranging from 24 to 72 hours. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in response to known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

[1] Formerly the Western Environmental Research Laboratory.

[2] The ASN is operated under a Memorandum of Understanding (No. AT26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

Results

Table 2 presents the monthly average gross beta concentrations in air for each of the network stations. The highest gross beta concentration within the network was 0.2 pCi/m^3 at Kingman, Ariz. and Barstow, Calif.; and Hiko and Blue Jay, Nev. The minimum reporting concentration for gross beta is 0.1 pCi/m^3. For averaging purposes, individual concentrations which are below the minimum detectable concentration (0.06 pCi/m^3) are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reporting level (0.1 pCi/m^3) are reported as $<$ 0.1 pCi/m^3. No radionuclides were identified by gamma spectrometry on any filters or charcoal cartridges during May.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA regional offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

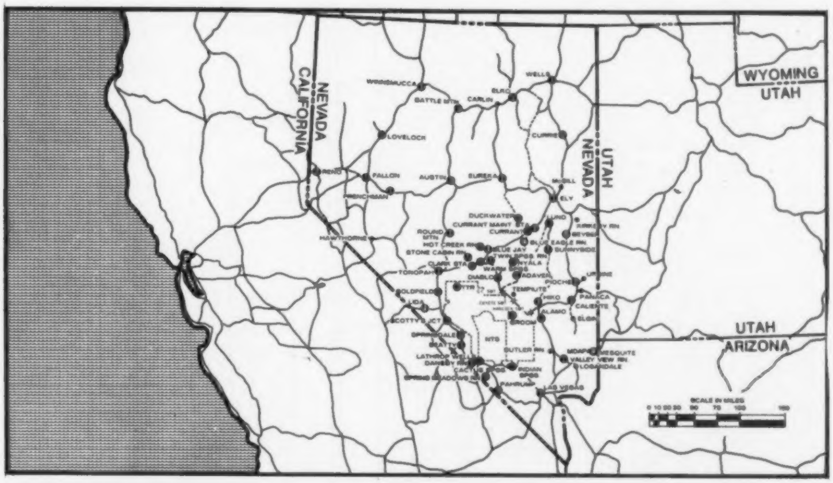

Figure 2. NERC-LV Air Surveillance Network stations in Nevada

Figure 3. NERC-LV Air Surveillance Network stations outside Nevada

Table 2. Summary of gross beta radioactivity concentrations in air, May 1973

Station		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average[a]
Ariz:	Kingman	31	0.2	<0.1	0.1
	Seligman	31	<.1	<.1	<.1
Calif:	Baker	26	.1	<.1	.1
	Barstow	31	.2	<.1	.1
	Bishop	30	<.1	<.1	<.1
	Death Valley Junction	31	<.1	<.1	<.1
	Furnace Creek	31	<.1	<.1	<.1
	Lone Pine	27	.1	<.1	.1
	Needles	21	<.2	<.1	<.1
	Ridgecrest	31	<.1	<.1	<.1
	Shoshone	31	<.1	<.1	<.1
Nev:	Alamo	31	<.1	<.1	<.1
	Austin	24	<.1	<.1	<.1
	Beatty	31	<.1	<.1	<.1
	Blue Eagle Ranch (Currant)	30	.1	<.1	.1
	Blue Jay	31	.2	<.1	.1
	Caliente	31	<.1	<.1	<.1
	Currant Ranch	24	<.2	<.1	<.1
	Diablo	31	<.1	<.1	<.1
	Duckwater	25	<.1	<.1	<.1
	Ely	31	<.1	<.1	<.1
	Eureka	30	<.1	<.1	<.1
	Fallini's Twin Springs Ranch	31	<.1	<.1	<.1
	Geyser Maintenance Station	31	<.1	<.1	<.1
	Goldfield	29	.1	<.1	.1
	Groom Lake	23	<.2	<.1	<.1
	Hiko	31	.2	<.1	.1
	Indian Springs	31	<.1	<.1	<.1
	Las Vegas	22	.1	<.1	.1
	Lathrop Wells	31	<.1	<.1	<.1
	Lida	31	<.1	<.1	<.1
	Lund	27	<.1	<.1	<.1
	Mesquite	31	<.1	<.1	<.1
	Nyala	31	<.1	<.1	<.1
	Pahrump	29	<.1	<.1	<.1
	Pioche	29	<.1	<.1	<.1
	Round Mountain	30	<.1	<.1	<.1
	Scotty's Junction	31	<.1	<.1	<.1
	Stone Cabin Ranch	31	<.1	<.1	<.1

See footnotes at end of table.

Table 2. Summary of gross beta radioactivity concentrations in air, May 1973—continued

Station	Number of samples	Concentration (pCi/m³) Maximum	Minimum	Average [a]
Nev: Sunnyside	31	<.3	<.1	<.1
Tonopah	31	<.1	<.1	<.1
Tonopah Test Range	25	.1	<.1	.1
Warm Springs	31	.1	<.1	.1
Warm Springs Ranch	31	<.1	<.1	<.1
Utah: Cedar City	29	<.2	<.1	<.1
Delta	31	<.2	<.1	<.1
Garrison	31	<.1	<.1	<.1
Milford	31	<.1	<.1	<.1
St. George	31	<.1	<.1	<.1

[a]Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m³ is reported as <0.1.

3. Canadian Air and Precipitation Monitoring Program,[3] May 1973

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 4), where the sampling equipment is operated by personnel from the Meteorological Service Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May

[3] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

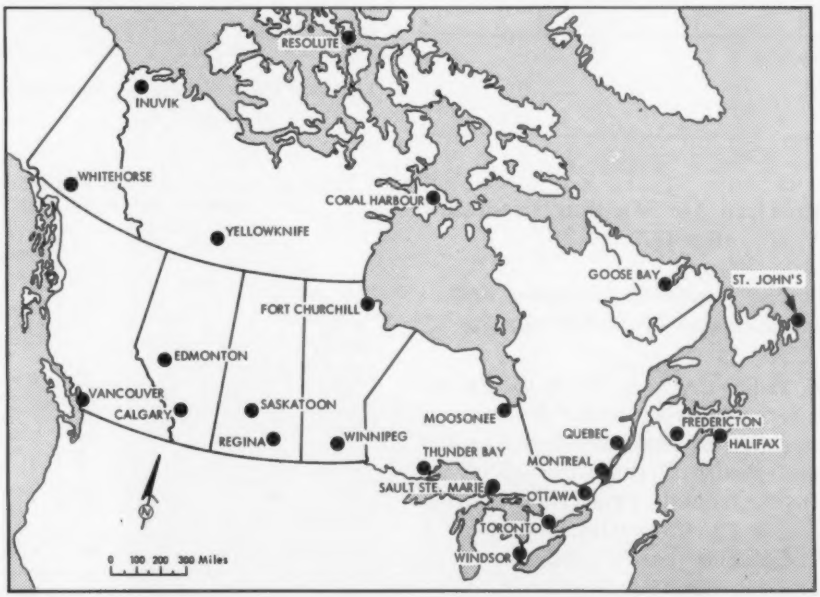

Figure 4. Canadian air and precipitation monitoring program

1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for May 1973 are presented in table 3.

Table 3. Canadian gross beta radioactivity in surface air and precipitation, May 1973

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³): Maximum	Minimum	Average	Precipitation measurements: Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	4	0.01	0.01	0.01	15	0.4
Coral Harbour	4	.02	.01	.01	15	.3
Edmonton	4	.02	.01	.01	16	.9
Ft. Churchill	4	.01	.01	.01	50	.3
Fredericton	4	.01	.01	.01	5	.5
Goose Bay	4	.01	<.01	.01	20	.7
Halifax	10	.02	.01	.01	21	.8
Inuvik	4	.02	.01	.01	22	.8
Montreal	4	.01	.01	.01	10	1.1
Moosonee	4	.03	.01	.02	NS	NS
Ottawa	3	.02	.01	.01	12	1.2
Quebec	4	.01	.01	.01	5	.9
Regina	4	.02	.01	.02	20	1.0
Resolute	4	.02	.01	.02	59	.1
St. John's, Nfld	2	.01	.01	.01	7	.9
Saskatoon	4	.02	.01	.02	23	.7
Sault Ste. Marie	4	.02	.01	.02	10	1.1
Thunder Bay	3	.01	.01	.01	18	.9
Toronto	4	.02	.01	.01	13	1.3
Vancover	4	.02	.01	.01	11	.5
Whitehorse	4	.01	.01	.01	26	.2
Windsor	4	.01	.01	.01	13	1.1
Winnipeg	4	.02	.02	.02	13	1.3
Yellowknife	3	.01	<.01	<.01	15	.2
Network summary	97	0.03	<0.01	0.01	18	0.7

NS, no sample available.

4. Pan American Air Sampling Program May 1973

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports.* The May 1973 air monitoring results from the participating countries are given in table 4.

Figure 5. Pan American Air Sampling Program stations

Table 4. Summary of gross beta radioactivity in Pan American surface air, May 1973

Station location		Number of samples	Gross beta radioactivity (pCi/m³): Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	11	0.01	0.01	0.01
Chile:	Santiago	28	.04	.00	.02
Colombia:	Bogota	21	.05	.00	.01
Ecuador:	Cuenca	8	.00	.00	.00
	Guayaquil	19	.02	.01	.01
	Quito	18	.00	.00	.00
Guyana:	Georgetown	0			
Jamaica:	Kingston	0			
Peru:	Lima	20	.05	.01	.02
Venezuela:	Caracas	11	.05	.00	.01
West Indies:	Trinidad	9	.07	.00	.06
Pan American summary		145	0.07	0.00	0.01

[a]The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging 0.00 pCi/m³.

5. California Air Sampling Program May 1973

Bureau of Radiological Health
California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 6.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 5 presents the monthly gross beta radioactivity in air for May 1973. The monthly sample results are presented quarterly.

Figure 6. California air sampling program stations

Table 5. Gross beta radioactivity in California air May 1973

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	28	0.69	0.04	0.17
Barstow	31	.59	.00	.15
Berkeley	31	.09	.00	.04
El Centro	30	.79	.02	.13
Eureka	29	.09	.00	.03
Fresno	31	.96	.05	.17
Los Angeles	31	.14	.00	.05
Redding	29	.28	.03	.10
Sacramento	31	.35	.00	.10
Salinas	31	.95	.00	.14
San Bernardino	31	.45	.05	.10
San Diego	31	.07	.01	.05
San Luis Obispo	31	.50	.00	.12
Santa Rosa	29	.20	.00	.07
Summary	424	0.96	0.00	0.10

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Surface Air Sampling Program–80th Meridian Network[1] January–December 1971

Health and Safety Laboratory
Atomic Energy Commission

The Health and Safety Laboratory (HASL), began its Surface Air Sampling Program in January 1963, as a continuation of the 80th Meridian Program conducted by the U.S. Naval Research Laboratory. The objective of this program is to study the spatial and temporal distribution of nuclear weapons debris and lead in the surface air.

The basic network consists of a line of sites approximately along the 80th meridian extending from about 81° N to 90° S latitudes (figure 1). Since 1963, a number of sites have been added to investigate the possible effects of longitude, elevation, and proximity to coastlines; and from late 1965 through March 1969, samplers were placed on four Atlantic Ocean weather ships to extend the surface air study over the marine environment (table 1).

Table 1. Station location

Site	Latitude	Longitude (west)	Elevation (meters)
Greenland: Nord	81° 40′ N	17° 00′	250
Thule	76° 36′ N	68° 35′	259
Ontario: Moosonee	51° 16′ N	80° 30′	10
N.Y: New York City	40° 48′ N	73° 58′	38
Utah: Salt Lake City	40° 46′ N	110° 49′	1,516
Va: Sterling	38° 58′ N	77° 25′	76
Fla: Miami	25° 49′ N	80° 17′	4
Bahamas: Bimini	25° 46′ N	79° 22′	8
Hawaii: Mauna Loa	19° 28′ N	155° 36′	3,401
P.R: San Juan	18° 26′ N	66° 00′	10
Panama Canal Zone: Balboa	8° 58′ N	79° 34′	23
Ecuador: Guayaquil	2° 10′ S	79° 52′	7
Peru: Lima	12° 01′ S	77° 08′	13
Bolivia: Chacaltaya	16° 21′ S	68° 07′	5,220
Chile: Antofagasta	23° 37′ S	70° 16′	31
Isle de Pasqua	27° 10′ S	109° 26′	41
Santaigo	33° 27′ S	70° 42′	520
Puerto Montt	41° 27′ S	72° 57′	7
Punta Arenas	53° 08′ S	70° 53′	35
Antaractica[a]	62° 56′ S	60° 36′	16
	64° 49′ S	62° 52′	10
South Pole Station	90° 00′ S	----------	2,800

[a]The Chilean Antarctic station has moved at least three times within an area of about 2° latitude and longitude. For simplicity, the individual station names were dropped and all data grouped under "Antarctica."

Sampling and analytical procedures

Approximately 1,400 cubic meters of ambient air per day are drawn through an 8-inch diameter microsorban filter for the land stations. For the ocean stations, about 2,200 cubic meters of air per day were filtered by an 8- by 10-inch microsorban filter. Each filter is changed on the 1st, 8th, 15th, and 22nd of the month or more frequently if the filter becomes clogged with debris suspended in the air.

The filters are returned to HASL at the end of each month and under normal conditions, composited into monthly samples for analysis. Until late 1969, the composited sample was first gamma counted and then sent to a contractor laboratory for radiochemical analysis. In the current program, each sample is split into equal aliquots, one for gamma counting and spectrometry and the other for radiochemistry and stable lead analysis. Hence, half of each sample is now being kept and stored for possible future work.

Daily pump pressure drop and temperature readings also are submitted to HASL along with the samples for the purpose of computing the volume of sampled air.

Gamma analysis

The gamma activity of half of the monthly composites are obtained with an 8- by 4-inch sodium iodide (Tl) crystal as soon as possible after receipt of the samples. The integrated response between 100 keV and 3.0 MeV is corrected by the average detection efficiency (35 percent) of the gamma photons present in fallout; and the total gamma activities are reported in units of photons per minute per standard cubic meter.

[1] Summarized from "Fallout Program Quarterly Summary Report," HASL 273 (April 1, 1973) available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

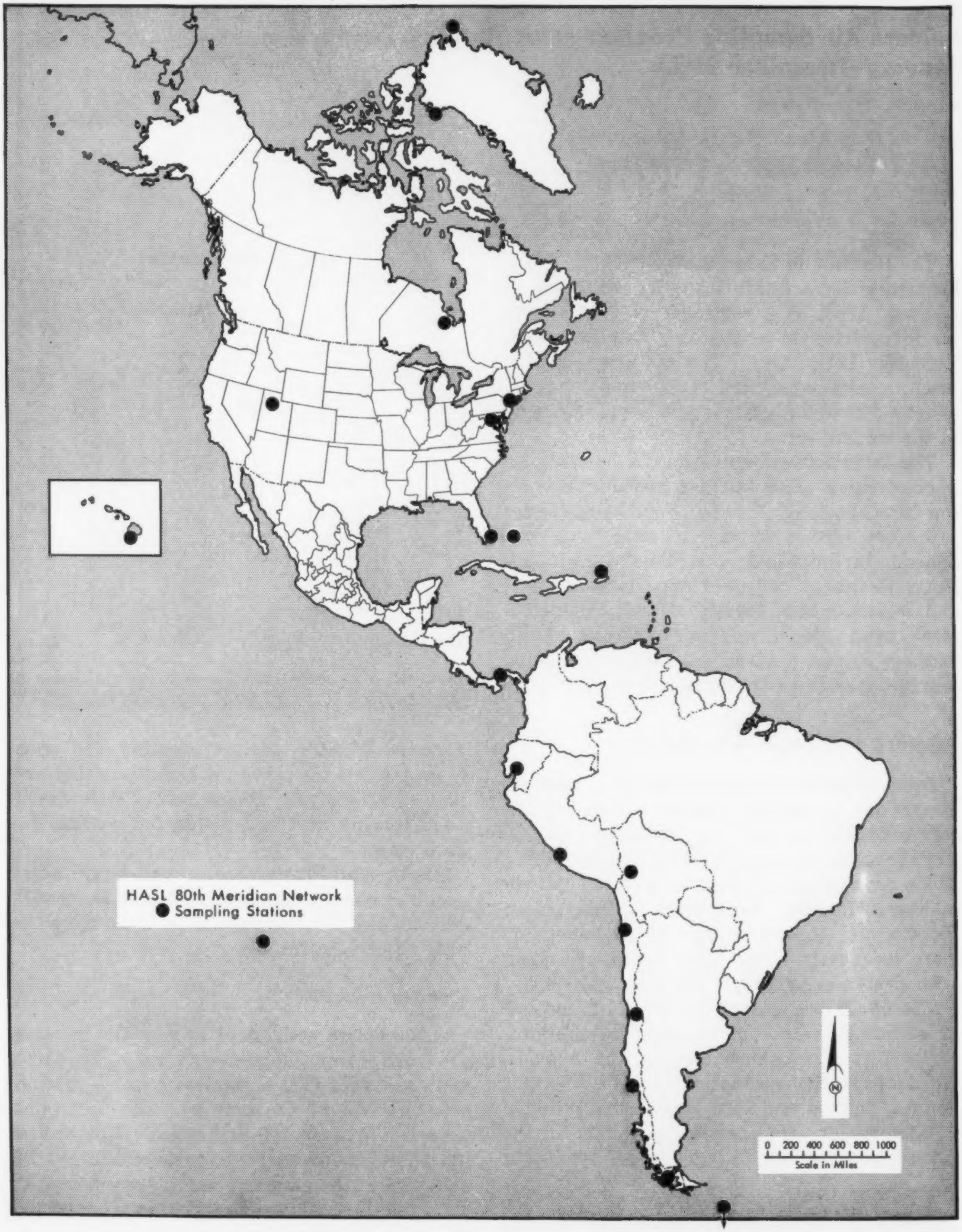

Figure 1. HASL 80th Meridian Network sampling stations

Table 2. Strontium-89 concentrations in surface air, 1971[a]

Site	Concentration (fCi/m³)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland: Nord	1.04	9.28	5.06	12.5	9.4	8.6	4.89	2.59	0.83	1.07	[b] 0.56	0.73
Thule	3.49	—	21.8	29.9	19.1	20.1	10.7	4.98	1.45	1.89	1.43	3.41
Ontario: Moosonee	1.79	1.91	10.7	18.5	31.1	25.9	14.0	7.95	2.55	1.87	—	—
N.Y: New York City	4.35	16.4	12.0	16.1	34.5	32.7	20.8	10.5	3.19	1.06	.81	2.05
Utah: Salt Lake City	10.1	9.01	28.8	56.8	65.3	55.5	28.9	8.26	4.09	1.75	6.21	10.3
Va: Sterling	2.3	6.79	15.6	31.	38.8	22.6	15.4	7.61	2.02	1.12	[b] .57	1.08
Fla: Miami	8.02	15.5	29.1	42.1	38.3	15.1	11.7	3.56	2.96	.94	[b] .59	—
Bahamas: Bimini	5.8	26.	48.7	43.3	58.1	16.6	13.1	3.97	3.72	2.42	6.43	—
Hawaii: Mauna Loa	16.2	26.5	46.8	21.4	38.1	42.3	13.1	6.41	5.71	1.78	1.31	[b] .76
P.R: San Juan	5.83	16.5	28.5	—	—	—	—	—	—	—	[b] .45	1.02
Panama Canal Zone: Balboa	—	—	—	—	7.96	7.16	7.75	4.01	4.39	1.19	.44	.97
Ecuador: Guayaquil	4.7	2.52	.84	1.24	[b] .5	7.62	30.4	7.72	13.5	2.79	3.56	1.95
Peru: Lima	14.6	8.65	8.64	—	4.15	42.0	187	88.6	106	62.6	52.2	45.1
Bolivia: Chacaltaya	5.04	.84	[b] 1.77	1.15	1.93	143	445	182	254	93.9	—	11.4
Chile: Antofagasta	14.8	8.68	6.68	4.89	2.48	63.4	301	208	25.4	57.7	39.9	15.1
Isle de Pasqua	—	—	5.26	1.51	.93	48.4	53.4	13.9	31.7	26.3	18.7	12
Santiago	22.1	—	9.46	7.08	2.3	45	148	72.1	58.5	36	11.9	[b] 3.38
Puerto Montt	6.16	9.71	6.92	3.03	2.71	2.53	25.6	56.9	18.8	14.1	8.95	7.16
Punta Arenas	1.42	3.27	3.03	—	.89	1.26	8.37	—	—	—	—	—
Antarctica	([c])	([c])	([c])	[b] 49.8	[b] 9.79	[b] 5.51	10.2	[b] 8.22	[b] 4.42	[b] 2.73	([c])	5.43
South Pole Station	4.52	17.3	[b] 10.5	7.61	6.86	[b] 1.28	3.15	9.15	10.9	10.1	10.4	18.6

[a] Errors are less than 20 percent except:
[b] Error between 20–100 percent;
[c] Error greater than 100 percent.
—, no data reported.

Table 3. Strontium-90 concentrations in surface air, 1971[a]

Site	Concentration (fCi/m³)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland: Nord	0.96	0.28	2.19	2.70	2.13	1.92	1.56	1.08	.48	.45	.83	.44
Thule	2.01	2.27	4.65	4.83	3.31	2.64	3.54	2.32	1.03	.48	.92	1.32
Ontario: Moosonee	1.07	.75	2.8	3.06	5.81	6.66	5.21	3.97	1.87	1.06	—	—
N.Y: New York City	1.12	3.92	3.28	2.93	5.09	6.86	7.37	3.75	2.27	.62	.52	.81
Utah: Salt Lake City	1.88	2.43	3.57	8.34	11.	11.6	7.74	4.11	3.21	1.49	1.09	1.55
Va: Sterling	1.16	1.34	2.98	4.79	5.85	4.70	5.27	2.6	1.43	.57	.67	.88
Fla: Miami	2.55	2.37	4.73	7.03	6.47	3.41	3.81	1.39	.63	.45	1.15	—
Bahamas: Bimini	1.74	4.34	6.79	6.42	8.45	3.37	4.01	1.58	.99	1.21	4.47	—
Hawaii: Mauna Loa	2.41	2.21	3.75	2.44	6.49	9.38	4.61	2.07	1.32	.91	.81	1.11
P.R: San Juan	1.04	1.76	3.97	—	—	—	—	—	—	—	.46	.78
Panama Canal Zone: Balboa	—	—	—	—	1.3	1.51	1.75	.66	.17	.08	[b] .16	.58
Ecuador: Guayaquil	.57	.35	.24	.34	.25	.19	.46	.29	.26	.1	.22	.21
Peru: Lima	1.75	1.52	2.79	—	2.04	.92	2.25	2.58	2.44	2.31	2.36	4.15
Bolivia: Chacaltaya	.55	.16	.42	.38	1.03	2.3	5.34	2.63	3.38	3.06	—	1.17
Chile: Antofagasta	2.04	1.71	2.02	1.35	.94	1.74	4.51	4.12	.61	2.30	2.43	1.75
Isle de Pasqua	—	—	1.06	.59	.41	.42	1.09	.55	1.33	1.47	1.54	1.19
Santiago	2.81	—	2.57	3.44	1.28	1.46	2.91	2.57	2.14	1.86	1.09	1.17
Puerto Montt	1.13	2.05	1.76	1.42	1.09	.64	.86	.73	.84	.70	.95	.87
Punta Arenas	.48	.7	.88	—	.73	.53	.66	—	—	—	—	—
Antarctica	.64	.7	.57	.57	.49	.12	.39	.36	.32	.29	6.19	.46
South Pole Station	.99	1.92	1.31	1.49	1.12	.58	.67	.79	.89	1.04	1.18	3.25

[a] Errors are less than 20 percent except:
[b] Error between 20–100 percent.
—, no data reported.

Table 4. Zirconium-95 concentrations in surface air, 1971[a]

Site		Concentration (fCi/m³) Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Nord	2.57	5.46	19.1	—	25.9	25.3	19.2	8.41	4.1	[b] 4.43	[b] 2.95	—
	Thule	6.05	11.8	22.6	49.5	—	40.8	34.5	15.6	6.87	[b] 3.85	3.47	[b] 1.73
Ontario:	Moosonee	3.71	5.19	29.8	47.0	—	94.4	58.7	32.6	11.8	[b] 2.94	—	—
N.Y:	New York City	4.58	11.1	37.7	53.6	92.1	92.3	67.9	39.4	—	6.05	2.51	2.04
Utah:	Salt Lake City	14.6	—	89.2	181	226	168	[b] 77.8	[b] 29.8	9.3	14.6	3.99	2.16
Va:	Sterling	6.01	—	38.3	—	116	71.4	57.8	26.2	8.54	4.62	(c)	2.08
Fla:	Miami	20.6	46.1	111	125	—	62.0	34.3	11.7	8.7	[b] 6.77	[b] 7.83	—
Bahamas:	Bimini	18.2	—	150	—	—	69.5	43.8	14.8	[b] 6.27	[b] 4.43	[b] 8.54	—
Hawaii:	Mauna Loa	43.8	86.8	125	—	105	122	43.4	16.9	13.2	5.27	—	[b] 3.48
P.R:	San Juan	14.7	38.3	87.5	—	—	—	—	—	—	—	[b] 4.95	2.64
Panama													
Canal Zone:	Balboa	—	—	—	—	26.4	19.8	21.9	10.5	6.62	[b] 3.67	[b] .6	—
Ecuador:	Guayaquil	13.9	11.0	[b] 2.89	4.62	[b] .54	27.1	77.9	28.7	—	53.7	40.6	24.4
Peru:	Lima	46.6	31.0	—	—	17.2	97.1	311	139	192	—	108	86.7
Bolivia:	Chalcaltaya	[b] 1.06	2.51	—	[b] 5.23	[b] 11.6	298	593	293	424	189	—	22.0
Chile:	Antofagasta	44.2	—	25.3	—	8.63	115	471	261	97.1	126	89.3	46.6
	Isle de Pasqua	—	—	[b] 15.7	—	[b] 1.81	65.9	96.6	34.1	53.9	47.9	37.3	22.6
	Santiago	66.8	—	34.6	33.6	[b] 9.36	—	—	154	112	116	78.8	63.1
	Puerto Montt	20.1	20.4	19.9	12.2	—	—	—	27.9	39.6	27.4	23.6	19.6
	Punta Arenas	9.16	10.9	9.14	—	.57	—	13.5	—	—	—	—	—
Antarctica		[b] 278	[b] 29.7	[b] 43.6	(c)	(c)	—	[b] 11.8	—	7.85	11.0	3.98	5.91
South Pole Station		32.7	[b] 7.62	[b] 23.2	[b] 43.8	13.7	[b] 4.01	10.0	20	23.7	25.1	17.3	44.5

[a] Errors are less than 20 percent except:
[b] Error between 20–100 percent;
[c] Error greater than 100 percent.
—, no data reported.

Table 5. Cesium-137 concentrations in surface air, 1971[a]

Site		Concentration (fCi/m³) Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Nord	2.01	2.02	4.08	—	3.44	3.22	2.73	1.81	1.27	1.13	1.33	1.23
	Thule	3.83	4.16	3.07	6.0	—	5.17	5.68	3.95	2.16	1.86	1.63	13.0
Ontario:	Moosonee	2.46	1.6	4.92	5.65	—	12.0	8.91	6.78	3.86	1.84	—	—
N.Y:	New York City	2.31	2.54	5.28	6.14	10.2	11.7	10.8	8.51	----	2.31	1.37	1.58
Utah:	Salt Lake City	1.86	----	8.48	17.2	21.2	21.9	11.8	5.54	4.38	2.78	2.36	2.27
Va:	Sterling	2.32	----	4.48	----	12.0	8.59	9.63	5.77	2.43	1.51	1.32	1.61
Fla:	Miami	5.14	6.8	10.3	12.1	----	6.89	5.65	2.33	1.56	.98	2.67	----
Bahamas:	Bimini	5.11	----	14.2	----	----	8.31	6.5	3.1	[b] 2.11	[b] 2.01	4.94	----
Hawaii:	Mauna Loa	4.78	5.97	8.43	----	9.16	13.9	7.21	3.46	2.21	1.92	[b] 1.31	[b] 1.79
P.R:	San Juan	2.35	3.1	7.54	—	—	—	—	—	—	—	[b] .87	1.59
Panama													
Canal Zone:	Balboa	—	—	—	—	2.24	2.68	2.84	1.27	(c)	[b] .26	(c)	[b] .93
Ecuador:	Guayaquil	1.02	.91	[b] .43	.72	[b] .40	.59	.95	.7	—	1.0	2.2	1.74
Peru:	Lima	3.69	3.22	—	—	4.03	2.03	3.67	3.51	4.59	—	5.41	6.12
Bolivia:	Chacaltaya	.79	.26	[b] .68	.56	1.64	4.44	6.69	[b] 3.43	6.53	5.07	—	—
Chile:	Antofagasta	4.24	—	[b] .34	—	1.8	3.25	6.99	7.53	2.52	5.59	5.67	4.37
	Isle de Pasqua	—	—	1.91	.75	.64	.95	1.65	.99	2.1	1.81	2.54	1.69
	Santiago	6.55	—	4.96	5.74	2.22	—	—	5.59	3.54	4.18	4.09	4.87
	Puerto Montt	2.24	2.15	2.93	2.44	—	—	—	1.13	1.32	[b] 1.66	1.75	1.82
	Punta Arenas	1.00	1.37	1.21	—	.95	—	.86	—	—	—	—	—
Antarctica		[b] 1.59	.94	(c)	.74	.59	[b] .27	.49	—	.67	.47	[b] .63	.8
South Pole Station		3.45	3.55	2.98	2.85	2.31	1.1	1.35	1.53	1.48	2.01	1.6	5.19

[a] Errors are less than 20 percent except:
[b] Error between 20–100 percent;
[c] Error greater than 100 percent.
—, no data reported.

Table 6. Cerium-144 concentrations in surface air, 1971[a]

Site		Concentration (fCi/m³)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Nord	13.1	15.1	29.7	—	32.9	37.5	33.2	19.3	13.5	10.5	11.1	8.55
	Thule	26.9	27.8	28.2	60.0	—	62.4	67.1	45.	20.8	18.7	14.2	7.72
Ontario:	Moosonee	15.7	11.1	40.9	53.5	—	144	105	85.3	35.1	17.9	—	—
N.Y:	New York City	16.3	18.5	44.8	59.1	112	132	128	91.6	—	21.4	11.0	11.3
Utah:	Salt Lake City	15.6	—	84.1	191	256	282	152	69.5	44.6	28.9	17.6	16.7
Va:	Sterling	17.4	—	46.5	—	144	106	110	63.	26.4	17.6	9.68	13.3
Fla:	Miami	36.3	58.9	103	132	—	88.9	63.2	27.6	18.7	9.84	21.5	—
Bahamas:	Bimini	36.8	—	136	—	—	100	86.4	32.2	26.8	16.7	38.9	—
Hawaii:	Mauna Loa	38.4	57.6	99.9	—	116	172	81.1	35.5	24.0	13.5	12.8	17.1
P.R:	San Juan	19.0	31.5	76.9	—	—	—	—	—	—	—	9.84	12.3
Panama Canal Zone:	Balboa	—	—	—	—	29.4	30.5	36.1	16.8	3.88	2.77	[b]4.69	9.44
Ecuador:	Guayaquil	13.9	9.97	4.51	7.47	4.27	7.93	19.3	11.2	—	23.5	27.9	20.9
Peru:	Lima	44.0	35.5	—	—	37.5	29.1	80.2	58.0	67.5	—	76.0	87.7
Bolivia:	Chacaltaya	9.84	2.82	7.75	6.06	15.0	75.5	152	80.6	132	87.4	—	23.5
Chile:	Antofagasta	45.3	—	—	—	15.4	39.5	130	122	43.6	72.6	61.3	47.7
	Isle de Pasqua	—	—	20.1	10.5	6.64	18.9	28.8	13.7	27.7	25.6	27.8	20.6
	Santiago	67.4	—	52.1	59.8	22.0	—	—	65.2	52.0	65.1	63.7	66.1
	Puerto Montt	20.4	24.5	29.8	25.8	—	—	—	16.3	19.3	19.4	21.5	18.7
	Punta Arenas	10.3	13.6	13.8	—	8.52	—	10.2	—	—	—	—	—
Antarctica		18.7	8.3	8.74	6.92	6.31	2.66	5.77	6.25	5.52	6.47	4.57	9.39
South Pole Station		33.3	37.0	30.7	30.8	24.5	11.4	12.4	15.7	16.2	22.8	19.5	52.2

[a] Errors are less than 20 percent except:
[b] Error between 20–100 percent.
—, no data reported.

Table 7. Plutonium-238 concentrations in surface air, 1971[a]

Site		Concentration (aCi/m³)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Nord	[b]5.73	[b]4.09	[b]4.17	[b]5.73	[b]5.88	[b]4.04	[b]1.4	[b]3.56	[b]1.19	[b]1.41	([c])	([c])
	Thule	[b]7.51	8.09	8.72	7.79	[b]6.72	[b]3.17	[b]3.02	[b]1.63	([c])	1	[b]4.31	([c])
Ontario:	Moosonee	[b]2.15	[b]1.47	[b]4.20	15.4	[b]6.52	7.46	[b]5.77	([c])	[b]3.24	([c])	—	—
N.Y:	New York City	20.6	103	27.8	9.24	11.2	10.3	10.1	14.9	5.88	3.50	3.24	5.1
Utah:	Salt Lake City	[b]6.89	[b]4.49	8.94	14.1	13.5	10.8	8.26	[b]4.43	[b]3.77	[b]2.22	[b]2.11	[b]2.37
Va:	Sterling	[b]1.55	6.72	6.18	[b]3.83	10.3	[b]4.24	[b]2.84	[b]3.26	([c])	([c])	[b]1.95	([c])
Fla:	Miami	[b]8.19	7.66	11.7	16.5	7.52	[b]5.45	[b]2.86	[b]3.61	([c])	([c])	([c])	—
Bahamas:	Bimini	9.21	9.5	10.6	9.57	17.1	[b]7.58	[b]2.49	7.75	([c])	[b]3.77	([c])	—
Hawaii:	Mauna Loa	[b]12.4	7.4	[b]4.62	36.7	25.4	16.6	12.1	9.9	[b]8.23	[b]2.15	[b]2.22	([c])
P.R:	San Juan	[b]4.55	5.46	[b]9.31	—	—	—	—	—	—	—	[b]3.12	([c])
Panama Canal Zone:	Balboa	—	—	—	—	[b]2.2	[b]5.70	[b]1.44	[b]3.35	[b]2.07	([c])	([c])	([c])
Ecuador:	Guayaquil	[b]4.77	[b]1.84	([c])	[b]2.60	[b]2.82	[b]2.35	[b]4.39	[b]1.64	[b]2.85	[b]3.08	([c])	([c])
Peru:	Lima	8.53	7.53	[b]8.87	—	[b]4.35	8.77	11.4	11.3	4.35	[b]4.44	[b]9.29	[b]4.63
Bolivia:	Chacaltaya	11.6	[b]2.38	[b]1.72	235	[b]1.6	[b]15.8	10.1	[b]7.68	[b]4.14	[b]6.81	—	([c])
Chile:	Antofagasta	12.0	[b]6.33	[b]3.40	[b]5.11	[b]4.4	18.7	22.4	12.6	[b]2.09	[b]5.29	[b]2.33	[b]2.10
	Isle de Pasqua	—	—	[b]4.20	[b]3.14	[b]3.26	[b]2.54	[b]3.68	[b]2.71	4.65	[b]3.44	[b]2.78	([c])
	Santiago	17.2	—	7.38	[b]10.4	6.62	[b]10.3	8.72	[b]9.85	[b]4.53	7.94	5.91	[b]2.55
	Puerto Montt	([c])	[b]4.44	5.17	[b]3.27	[b]2.60	16.2	7.23	[b]2.73	[b]3.12	([c])	[b]2.25	[b]2.02
	Punta Arenas	4.97	[b]5.45	[b]6.05	—	[b]1.88	[b]4.12	15.6	—	—	—	—	—
Antarctica		([c])	([c])	[b]1.76	[b]1.87	[b]1.15	([c])	[b]2.61	[b]1.26	[b]3.51	([c])	([c])	([c])
South Pole Station		8.32	23.7	[b]4.77	[b]7.51	[b]2.7	—	[b]2.75	[b]5.34	7.43	10.4	[b]4.55	[b]3.79

[a] Errors are less than 20 percent except:
[b] Error between 20–100 percent;
[c] Error greater than 100 percent.
—, no data reported.

Table 8. Plutonium-239 concentrations in air, 1971[a]

Site		Concentration (aCi/m³) Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Nord	18.5	22.6	31.1	44.1	34.2	35.3	28.3	16.7	14.5	12.4	[b] 17.0	11.9
	Thule	34.1	40.7	83.5	93.1	62.3	50.8	67.1	39.7	14.0	—	18.9	20.8
Ontario:	Moosonee	20.6	14.7	46.2	71.2	100	126	98.4	53.7	33.8	21.6	—	—
N.Y:	New York City	26.6	22.3	44.4	59.3	111	133	135	92.6	38.3	25.6	14.2	16.2
Utah:	Salt Lake City	31.8	47.4	83.9	203	238	315	154	88.9	60.7	37.0	32.9	33.5
Va:	Sterling	22.6	30.9	52.0	81.4	118	84.2	100	57.0	27.7	19.0	18.6	17.7
Fla:	Miami	53.6	67.2	106	142	125	76.4	67.7	25.2	17.4	7.94	22.7	—
Bahamas:	Bimini	50.8	81.3	136	137	168	87.5	79.9	33.1	20.3	20.8	59.9	—
Hawaii:	Mauna Loa	[b] 43.3	47.4	69.0	38.4	110	162	80.5	39.8	22.3	20.8	20.2	18.8
P.R:	San Juan	26.7	32.0	57.9	—	—	—	—	—	—	—	9.52	15.8
Panama Canal Zone:	Balboa	—	—	—	—	22.4	33.3	30.8	13.0	[b] 1.82	[b] .81	[b] 3.63	13.0
Ecuador:	Guayaquil	29.2	8.1	[b] 3.27	5.66	[b] 6.36	15.3	58.1	5.11	6.67	14.0	18.9	7.75
Peru:	Lima	35.2	36.5	36.8	—	52.6	68.9	143	56.3	29.8	40.8	36.7	48.5
Bolivia:	Chacaltaya	10.5	[b] 1.64	[b] 4.25	[b] 11.7	[b] 5.88	190	78.9	25.5	50.7	36.7	—	[b] 7.11
Chile:	Antofagasta	37.0	42.6	28.2	22.7	23.2	55.4	213	70.4	16.1	32.6	26.7	23.6
	Isle de Pasqua	—	—	19.3	8.39	7.13	19.9	45.6	8.03	15.8	13.3	14.1	12.9
	Santiago	55.4	—	36.6	50.9	18.2	80.8	55.8	61.5	27.4	32.7	23.6	24.3
	Puerto Montt	[b] 71.5	24.1	26.7	17.2	19.3	25.3	23.8	12.2	11.6	[b] 18.6	11.0	12.9
	Punta Arenas	11.3	12.5	[b] 16.8	—	10.3	11.4	11.3	—	—	—	—	—
Antarctica		16.2	11.3	8.89	8.91	7.97	3.56	13.0	6.79	4.30	4.48	4.18	8.69
South Pole Station		30.4	39.3	29.3	26.4	22.3	—	16.9	14.9	16.3	15.5	16.1	36.8

[a] Errors are less than 20 percent except:
[b] Errors between 20–100 percent.
—, no data reported.

Gamma spectra of the monthly composites are obtained using a lithium-drifted germanium diode (GeLi) system. Concentrations of the gamma emitting nuclides, beryllium–7, zirconium-95, cesium-137, and cerium-144 are determined by computer resolution of the spectra. Beginning in June 1970, all results from these nuclides, reported in the tables were obtained using this system.

Radiochemical analyses

The other halves of the monthly composites are sent to a contractor laboratory for radiochemical analyses.

There was no major weapon test series from the end of 1962 until May 1966. Consequently only the longer lived artificially produced radionuclides were present in the filters collected during this period and emphasis was given to the determination of manganese-54, iron-55, strontium-90, cadmium-109, cesium-137, cerium-144, plutonium-238, and plutonium-239. In samples collected after French or Chinese atmospheric weapons tests additional short-lived nuclides were analyzed, such as strontium-89, zirconium-95, and cerium-141.

The longer-lived fission products and plutonium-239 concentrations should describe the general distribution in surface air in all previous nuclear weapon debris which was transferred from the lower stratosphere to the troposphere during the collection period of this report. Other tracer nuclides can be associated with debris from a single detonation or series of detonations. Manganese-54 and iron-55 were produced in large quantities in the 1961 and 1962 test series. Cadmium-109 was generated by the U.S. high altitude test over Johnston Island on July 9, 1962. While plutonium-238 is present in low concentrations in nuclear weapons debris, about 17,000 curies of plutonium-238 was disseminated at high altitude in the stratosphere on April 21, 1964 during the reentry burnup of a SNAP–9A power source.

As the levels of any of the radionuclides drop to below practical detection limits they are eliminated from the radiochemical program; thus cadmium-109 was not analyzed after the end of 1967.

In response to the growing concern over air pollution and in particular to the known hazard linked to stable lead, analysis for this element was added to the program.

Most of the analyses of surface air samples were carried out from July 1969 to the present by the LFE-Environmental Analysis Laboratories.

Results

The radioactivity concentrations in surface air during January–December 1971 are presented in tables 2 through 8. The sites are listed according to latitude beginning with the most northern site at Nord, Greenland (table 1).

The concentrations are reported at the midpoint of the collection month for the plutonium isotopes and the fission products.

One standard deviation of the counting error for these data is always less than ±20 percent unless otherwise indicated.

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January-December 1970	May 1973

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors annual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

A summary of the environmental radioactivity data follows for the Feed Materials Production Center.

[1] Title 10, Code to Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Feed Materials Production Center[2] January–December 1971

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the Atomic Energy Commission (AEC). The location as related to populated areas is shown in figure 1. Cincinnati and Hamilton, the larger nearby communities, are situated 20 and 10 miles from the center, respectively.

The primary work at the FMPC is the production of purified uranium metal and compounds for use at other AEC sites. A small amount of thorium is also processed.

Uranium production may begin with ore concentrates, recycled uranium from spent reactor fuel, or with various compounds from other AEC sites. Impure starting material is dissolved in nitric acid and the uranium is extracted into an organic liquid and then back-extracted into dilute nitric acid to yield a solution of uranyl nitrate hexahydrate.

Evaporation and heating convert the nitrate solution to uranium trioxide (UO_3) powder. This compound is reduced to uranium dioxide (UO_2) with hydrogen and then converted to uranium tetrafluoride (UF_4) by reaction with anhydrous hydrogen fluoride. Uranium metal is produced by reacting UF_4 and magnesium metal in a refractory-lined vessel. This primary uranium metal is then remelted with scrap uranium metal to yield a purified uranium ingot which is rolled or extruded to form rods or tubes. Sections are then cut and machined to final dimensions. These machined cores are then shipped to other AEC sites for canning and final assembly into reactor fuel elements.

Thorium production steps, in general, are similar to those followed in uranium produc-

[2] Summarized from Environmental Monitoring at Major U.S. Atomic Energy Commission Contractor Sites; Feeds Material Production Center, 1971.

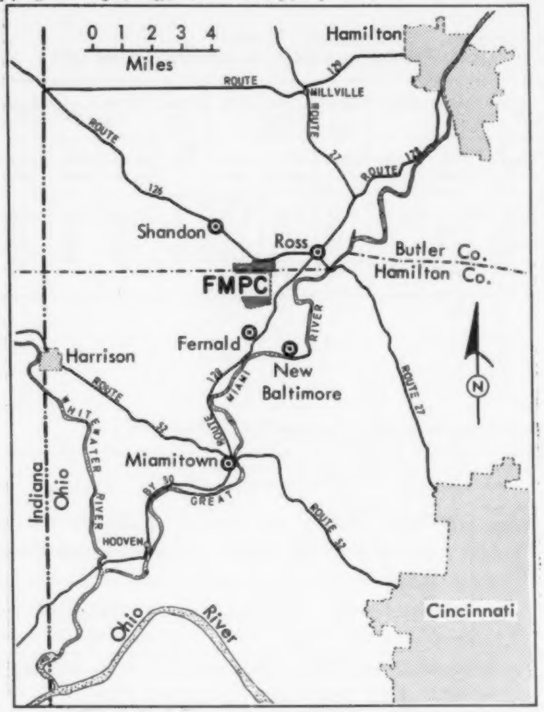

Figure 1. Area map of Feed Materials Production Center

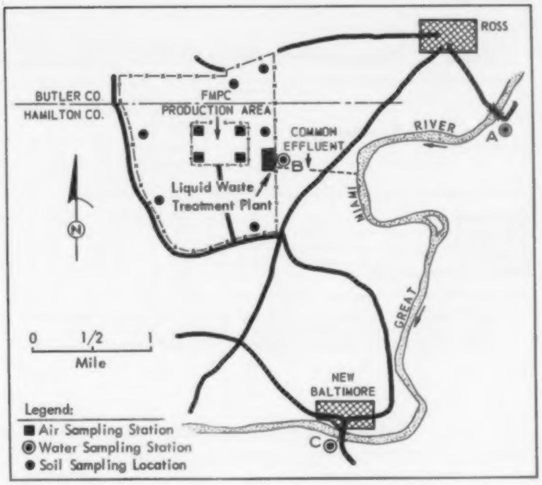

Figure 2. Air, water, and soil sampling stations, FMPC

tion. Final products may be purified thorium nitrate solution, solid thorium compounds, or metal.

Air monitoring

Conversion of impure uranium and thorium compounds to reactor-grade feed materials involves operations which generate radioactive dust, nuisance dusts, and corrosive mists or reaction products. Ventilation and air cleaning systems are used to confine this air and remove airborne contaminants, including valuable material which is returned to the production process. The filtered or scrubbed air is exhausted to the atmosphere. Sampling of these stack exhausts is maintained on a continuous schedule to monitor the operating condition of the air cleaning systems.

To determine the concentration of material which might reach the offsite air, samples were collected continuously at four locations around the production area and at the sewage treatment plant (STP) (figure 2). At each location a metered quantity of air was drawn through a filter which was changed weekly. Each filter and its collection of dust was dissolved and the solution analyzed for uranium and alpha and beta radioactivity. After these analyses, the remaining solutions were saved and composited for thorium analysis. Frequent analyses for thorium are not considered necessary because of the small amount of thorium processed.

During 1971, the only routine analysis made for nonradioactive contaminants was the determination of particulate matter. Filters used at the five sampling locations mentioned above plus one test adapter sampler at location (E) were weighed before use and then reweighed after changing to obtain the weight of collected dust.

A new air sampling schedule was started in January 1972, and includes occasional boundary sampling for oxides of nitrogen and sulfur dioxide. Occasional grab sampling for nitrogen oxide near the production area has shown that the concentration of this chemical is well within EPA limits but the boundary sampling will be carried out to provide documentation.

Data in table 1 show that the average radionuclide concentrations in air, at the onsite sampling stations, were no greater than 2 percent of their respective standards for offsite areas. It is concluded from these data that any offsite radiation exposure resulting from FMPC air-

Table 1. Radioactivity levels of airborne particulates, Feed Materials Production Center, January-December 1971

Location	Number of samples	Uranium concentration[a] (pCi/m³)			Alpha radioactivity[a] (pCi/m³)			Beta radioactivity[b] (pCi/m³)			Number of samples	Thorium concentrations[c] (pCi/m³)		
		Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average		Maximum	Minimum	Average
Southwest	50	0.37	<0.01	0.04	0.28	<0.001	0.04	0.43	0.04	0.16	6	0.58	0.18	0.39
Northwest	48	.13	<.01	.03	.14	<.001	.03	.52	.02	.16	6	.65	.10	.25
Northeast	52	.11	<.01	.03	.08	<.001	.03	.55	.03	.14	6	.66	.12	.30
Southeast	49	.20	<.01	.08	.15	<.001	.03	.40	.02	.15	6	.39	.08	.25
Sewage treatment plant	43	.11	<.01	.02	.15	<.001	.02	.60	.04	.15				

[a]AEC radiation protection standard—2 pCi/m³ (natural uranium).
[b]AEC radiation protection standard—1 nCi/m³ (thorium-234).
[c]AEC radiation protection standard—1 pCi/m³ (natural thorium).

Table 2. Particulate matter in air, Feed Material Production Center, January–December 1971

Location	Number of samples	Concentration (µg/m³)			Percent of standard	95–percent confidence level	Detection level	Standard[a]
		Maximum	Minimum	Average				
Southwest	7	57	28	46	61			
Northwest	5	70	37	57	76			
Northeast	6	77	46	64	85			
Southeast	4	64	38	55	73	±5	1 µg/m³	75 µg/m³
Sewage treatment plant	4	89	32	55	73			

[a]Environmental Protection Agency. Code of Federal Regulations, Title 42, Part 410, National Primary and Secondary Ambient Air Quality Standards, *Federal Register*, No. 84. April 30, 1971.

borne contaminants would be a small fraction (< 1 percent) of the AEC standards

The average concentrations of airborne particulate matter, given in table 2, are below the EPA standard. The highest average (Northeast) may have been due to the contribution from the nearby boiler plant.

Water monitoring

Each of the individual production plants on the project has collection sumps and treatment equipment for the initial treatment of process waste water. Uranium and thorium may be recovered as part of the treatment. Effluents from the plants are collected at a central facility, called the "general sump", for additional treatment. The treated wastes are then discharged into a large pit where the solids settle to the bottom. Clear effluent from the pit is combined with the other water streams and discharged to the Great Miami River.

Water samples are collected at several points to determine the effect of the effluent upon the river (figure 2). At point A, upstream from the effluent discharge, a weekly river water spot sample is taken for background analysis. At the final access point on the waste liquid line, a Parshal Flume-type water sampler collects a sample continuously which is proportional to the total flow. This sample is collected and analyzed on a daily basis. Results of this analysis, combined with daily river flow measurements, are used to calculate contaminant concentrations added to the river at point B. At point C, downstream on the river from the discharge point, 24-hour samples are collected by a continuous sampler. At least one sample is analyzed each week.

Samples from all collection points are analyzed for uranium, alpha, and beta radioactivity, radium-226, radium-228, chloride, fluoride, nitrate, filterable solids, and pH. Results of this monitoring have been reported to the Ohio Department of Health on a monthly basis since 1954.

Individual samples may be analyzed for other contaminants or they may be composited for varying periods and analyzed for lesser contaminants such as thorium.

Table 3 contains information on radionu-

Table 3. Radioactivity contaminants in water, Feeds Material Production Center, January–December 1971

Radionuclide	Sampling Location[a]	Number of samples	Concentration (pCi/liter)		
			Maximum	Minimum	Average
Uranium[b]	A	55	20	<1	3
	B	365	182	<1	2
	C	56	6	<1	2
Thorium[b]	B	[c] 12	.009	.0009	.00112
Radium-226	A	6	.908	<.445	.445
	B	15	.139	.004	.062
	C	6	.908	<.445	.445
Radium-228	A	12	.908	<.445	.445
	B	24	.058	<.002	.015
	C	12	.908	<.445	.445
Dissolved alpha	B	60	1.52	.161	.368
Gross beta	A	55	54	4	20
	B	365	921	<1	38
	C	56	45	9	18

[a] A, Miami River upstream at Ross, Ohio; B, calculated addition to the river based on effluent analyses and river flow; C, Miami River, downstream at New Baltimore, Ohio.
[b] In accordance with AEC Manual, a curie of natural uranium means a total of 7.49×10^{10} dps, and a curie of natural thorium means a total of 7.4×10^{10} dps.
[c] Each sample covers a 1-month period.

clides in water. As shown, the average concentrations of uranium, thorium, and radium added to the river was <1 percent of the AEC Radiation Protection Standards. The average upstream concentrations of radium-228 were 3.0 percent and 1.5 percent of the standard for uncontrolled areas. Although both radionuclides were present in the plant effluent, the average downstream concentrations were no higher than those found upstream.

As shown in table 3, the State criteria for gross beta and dissolved alpha radioactivity were not exceeded in the river. The calculated addition of dissolved gross alpha did average 12.3 percent of the State criteria. However, this alpha activity was due principally to uranium, for which the AEC limit is substantially higher. The more limiting State standard is intended to provide control over all alpha emitters, including radium-226 which must be kept at a concentration much lower than other less important radionuclides.

Soil monitoring

At least once each year, soil samples are collected at six locations inside the project boundary (figure 2). Each sample consists of six cores, 2 cm in diameter and 10 cm deep. The cores are taken about 1.5 meters apart. These samples are analyzed for uranium to observe the possible contribution from stack effluents.

There are no standards for comparison with the results for uranium in soil listed in table 4. The higher result is due to the localized contribution from the small onsite incinerator. Although the normal values for uranium in local soil is 1-4 μg/g, there are no hazards associated with the elevated soil uranium produced by FMPC operations. External radiation from uranium is slight and the exposure contribution from these onsite concentrations would be considerably less than 1 percent of the radiation protection standard for people in uncontrolled areas.

Table 4. Uranium in soil—onsite locations, Feed Materials Production Center, January–December 1971

Sampling point[a]	Number of samples	Uranium concentration			Detection level
		pCi/g (dry weight)	μg/g	95-percent confidence level	
1	1	2.2	10.1	±25 percent	0.5 μg/g
2	1	4.4	19.9		
3	2	21.3	95.8		
4	1	2.0	8.9		
5	1	3.8	17.0		
6	1	4.0	18.2		

[a] See sampling locations shown in figure 2.

Nuclear Power Reactors in the United States
June 30, 1973

Each quarter year, the Atomic Energy Commission releases information on the status of all present and proposed civilian nuclear power generating units in the United States. This information is reproduced for interested readers of *Radiation Data and Reports.*

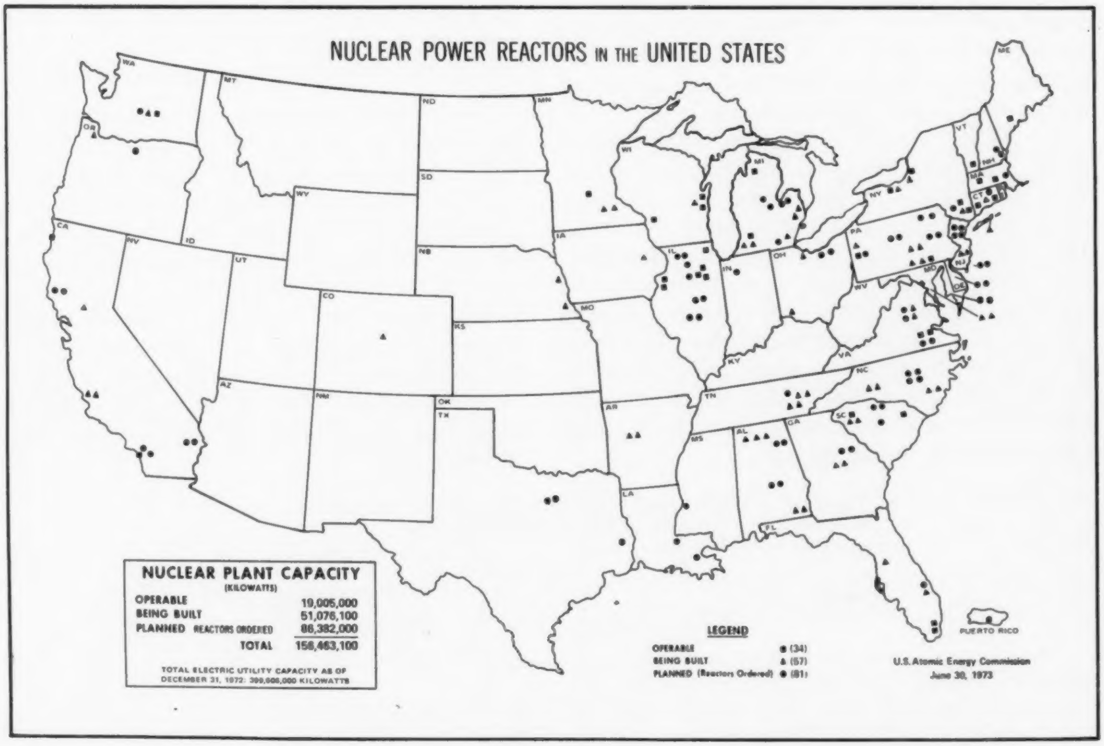

Figure 1. Nuclear power reactors in the United States, June 30, 1973

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant: Unit 1	1,065,000	Tennessee Valley Authority	1973
Decatur	Browns Ferry Nuclear Power Plant: Unit 2	1,065,000	Tennessee Valley Authority	1974
Decatur	Browns Ferry Nuclear Power Plant: Unit 3	1,065,000	Tennessee Valley Authority	1974
Dothan	Joseph M. Farley Nuclear Plant: Unit 1	829,000	Alabama Power Co.	1975
Dothan	Joseph M. Farley Nuclear Plant: Unit 2	829,000	Alabama Power Co.	1977
Orville	Central Alabama Nuclear Plant	1,100,000	Alabama Power Co.	1980
Orville	Central Alabama Nuclear Plant	1,100,000	Alabama Power Co.	1981
Scottsboro	Bellefonte Nuclear Plant: Unit 1	1,189,000	Tennessee Valley Authority	1979
Scottsboro	Bellefonte Nuclear Plant: Unit 2	1,189,000	Tennessee Valley Authority	1980
ARKANSAS				
Russellville	Arkansas Nuclear One: Unit 1	820,000	Arkansas Power & Light Co.	1973
Russellville	Arkansas Nuclear One: Unit 2	902,000	Arkansas Power & Light Co.	1976
CALIFORNIA				
Humboldt Bay	Humboldt Bay Power Plant: Unit 3	68,500	Pacific Gas and Electric Co.	1963
San Clemente	San Onofre Nuclear Generating Station: Unit 1	430,000	So. Calif. Ed. & San Diego Gas & El. Co.	1968
San Clemente	San Onofre Nuclear Generating Station: Unit 2	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1978
San Clemente	San Onofre Nuclear Generating Station: Unit 3	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	1979
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 1	1,060,000	Pacific Gas and Electric Co.	1975
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 2	1,060,000	Pacific Gas and Electric Co.	1976
Clay Station	Rancho Seco Nuclear Generating Station	804,000	Sacramento Municipal Utility District	1974
Pt. Arena	Mendocino Power Plant: Unit 1	1,128,000	Pacific Gas & Electric Co.	1981
Pt. Arena	Mendocino Power Plant: Unit 2	1,128,000	Pacific Gas & Electric Co.	1982
*	Eastern Desert Plant: Unit 1	770,000	Southern California Edison Co.	1981
*	Eastern Desert Plant: Unit 2	770,000	Southern California Edison Co.	1982
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1973
CONNECTICUT				
Haddam Neck	Haddam Neck Plant	575,000	Conn. Yankee Atomic Power Co.	1968
Waterford	Millstone Nuclear Power Station: Unit 1	652,100	Northeast Utilities	1971
Waterford	Millstone Nuclear Power Station: Unit 2	828,000	Northeast Utilities	1974
Waterford	Millstone Nuclear Power Station: Unit 3	1,150,000	Northeast Utilities	1979
DELAWARE				
Middletown	Delmarva Unit 1	770,000	Delmarva Power & Light Co.	1979
Middletown	Delmarva Unit 2	770,000	Delmarva Power & Light Co.	1982
FLORIDA				
Florida City	Turkey Point Station: Unit 3	693,000	Florida Power & Light Co.	1972
Florida City	Turkey Point Station: Unit 4	693,000	Florida Power & Light Co.	1973
Red Level	Crystal River Plant: Unit 3	825,000	Florida Power Corp.	1973
Ft. Pierce	St. Lucie Plant: Unit 1	801,000	Florida Power & Light Co.	1975
Ft. Pierce	St. Lucie Plant: Unit 2	801,000	Florida Power & Light Co.	1978
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant: Unit 1	786,000	Georgia Power Co.	1974
Baxley	Edwin I. Hatch Nuclear Plant: Unit 2	795,000	Georgia Power Co.	1978
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 1	1,121,000	Georgia Power Co.	1980
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 2	1,121,000	Georgia Power Co.	1981
ILLINOIS				
Morris	Dresden Nuclear Power Station: Unit 1	200,000	Commonwealth Edison Co.	1960
Morris	Dresden Nuclear Power Station: Unit 2	809,000	Commonwealth Edison Co.	1970
Morris	Dresden Nuclear Power Station: Unit 3	809,000	Commonwealth Edison Co.	1971
Zion	Zion Nuclear Plant: Unit 1	1,050,000	Commonwealth Edison Co.	1973
Zion	Zion Nuclear Plant: Unit 2	1,050,000	Commonwealth Edison Co.	1974
Cordova	Quad-Cities Station: Unit 1	800,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Cordova	Quad-Cities Station: Unit 2	800,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Seneca	LaSalle Co. Nuclear Station: Unit 1	1,078,000	Comm. Ed. Co.-Ia.	1977
Seneca	LaSalle Co. Nuclear Station: Unit 2	1,078,000	Comm. Ed. Co.-Ia.	1978
Byron	Byron Station: Unit 1	1,120,000	Comm. Edison Co.	1979
Byron	Byron Station: Unit 2	1,120,000	Comm. Edison Co.	1980
Braidwood	Braidwood: Unit 1	1,100,000	Comm. Edison Co.	1979
Braidwood	Braidwood: Unit 2	1,100,000	Comm. Edison Co.	1980
Clinton	Clinton Nuclear Power Plant: Unit 1	950,000	Illinois Power Co.	1980
Clinton	Clinton Nuclear Power Plant: Unit 2	950,000	Illinois Power Co.	1982
INDIANA				
Dune Acres	Bailly Generating Station	660,000	Northern Indiana Public Service Co.	1977
IOWA				
Palo	Duane Arnold Energy Center: Unit 1	529,700	Iowa Electric Light and Power Co.	1974
LOUISIANA				
Taft	Waterford Generating Station	1,113,000	Louisiana Power & Light Co.	1977
St. Francisville	River Bend Station	934,000	Gulf States Utilities Co.	1979

Figure 1. Nuclear power reactors in the United States, June 30, 1973—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co.	1972
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 1	845,000	Baltimore Gas and Electric Co.	1974
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 2	845,000	Baltimore Gas and Electric Co.	1975
Douglas Point	Douglas Point Project: Unit 1	1,178,000	Potomac Electric Power Co.	1980
Douglas Point	Douglas Point Project: Unit 2	1,178,000	Potomac Electric Power Co.	1981
MASSACHUSETTS				
Rowe	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co.	1961
Plymouth	Pilgrim Station: Unit 1	664,000	Boston Edison Co.	1972
Plymouth	Pilgrim Station: Unit 2	1,180,000	Boston Edison Co.	1978
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	70,300	Consumers Power Co.	1965
South Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co.	1971
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 2	1,123,000	Detroit Edison Co.	1976
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 3	1,125,000	Detroit Edison Co.	1979
Bridgman	Donald C. Cook Plant: Unit 1	1,060,000	Indiana & Michigan Electric Co.	1974
Bridgman	Donald C. Cook Plant: Unit 2	1,060,000	Indiana & Michigan Electric Co.	1975
Midland	Midland Nuclear Power Plant: Unit 1	492,000	Consumers Power Co.	1979
Midland	Midland Nuclear Power Plant: Unit 2	818,000	Consumers Power Co.	1980
St. Clair County	Greenwood: Unit 2	1,240,000	Detroit Edison Co.	1980
St. Clair County	Greenwood: Unit 3	1,240,000	Detroit Edison Co.	1981
Quanicassee	Quanicassee: Unit 1	1,150,000	Consumers Power Co.	1981
Quanicassee	Quanicassee: Unit 2	1,150,000	Consumers Power Co.	1982
MINNESOTA				
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co.	1971
Red Wing	Prairie Island Nuclear Generating Plant: Unit 1	530,000	Northern States Power Co.	1973
Red Wing	Prairie Island Nuclear Generating Plant: Unit 2	530,000	Northern States Power Co.	1974
MISSISSIPPI				
Port Gibson	Grand Gulf Nuclear Station	1,290,000	Mississippi Power & Light Co.	1979
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station: Unit 1	457,400	Omaha Public Power District	1973
Brownville	Cooper Nuclear Station	778,000	Nebraska Public Power District and Iowa Power and Light Co.	1973
NEW HAMPSHIRE				
Seabrook	–	1,100,000	Public Service of N.H.	1979
Seabrook	–	1,100,000	Public Service of N.H.	1981
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant: Unit 1	640,000	Jersey Central Power & Light Co.	1969
Forked River	Forked River Generating Station: Unit 1	1,070,000	Jersey Central Power & Light Co.	1978
Salem	Salem Nuclear Generating Station: Unit 1	1,090,000	Public Service Electric and Gas, N.J.	1975
Salem	Salem Nuclear Generating Station: Unit 2	1,115,000	Public Service Electric and Gas, N.J.	1976
Bordentown	Newbold Nuclear Generating Station: Unit 1	1,067,000	Public Service Electric and Gas, N.J.	1979
Bordentown	Newbold Nuclear Generating Station: Unit 2	1,067,000	Public Service Electric and Gas, N.J.	1980
Little Egg Inlet	Atlantic Generating Station: Unit 1	1,150,000	Public Service Electric and Gas, N.J.	1980
Little Egg Inlet	Atlantic Generating Station: Unit 2	1,150,000	Public Service Electric and Gas, N.J.	1981
NEW YORK				
Indian Point	Indian Point Station: Unit 1	265,000	Consolidated Edison Co.	1962
Indian Point	Indian Point Station: Unit 2	873,000	Consolidated Edison Co.	1973
Indian Point	Indian Point Station: Unit 3	965,000	Consolidated Edison Co.	1974
Scriba	Nine Mile Point Nuclear Station: Unit 1	625,000	Niagara Mohawk Power Co.	1969
Scriba	Nine Mile Point Nuclear Station: Unit 2	1,080,000	Niagara Mohawk Power Co.	1978
Ontario	R.E.Ginna Nuclear Power Plant: Unit 1	420,000	Rochester Gas & Electric Co.	1970
Brookhaven	Shoreham Nuclear Power Station	819,000	Long Island Lighting Co.	1977
Scriba	James A. Fitzpatrick Nuclear Power Plant	821,000	Power Authority of State of N.Y.	1973
*		1,150,000	Long Island Lighting Co.	1981
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant: Unit 1	821,000	Carolina Power and Light Co.	1975
Southport	Brunswick Steam Electric Plant: Unit 2	821,000	Carolina Power and Light Co.	1974
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 1	1,180,000	Duke Power Co.	1976
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 2	1,180,000	Duke Power Co.	1977
Bonsal	Shearon Harris Plant: Unit 1	915,000	Carolina Power & Light Co.	1978
Bonsal	Shearon Harris Plant: Unit 2	915,000	Carolina Power & Light Co.	1979
Bonsal	Shearon Harris Plant: Unit 3	915,000	Carolina Power & Light Co.	1980
Bonsal	Shearon Harris Plant: Unit 4	915,000	Carolina Power & Light Co.	1981
*	–	1,200,000	Duke Power Co.	1981
*	–	1,200,000	Duke Power Co.	1982
*	–	1,200,000	Duke Power Co.	1983
*	–	1,200,000	Duke Power Co.	1984
*	–	1,200,000	Duke Power Co.	1985
*	–	1,200,000	Duke Power Co.	1986

Figure 1. Nuclear power reactors in the United States, June 30, 1973—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	COMMERCIAL OPERATION
OHIO				
Oak Harbor	Davis-Besse Nuclear Power Station	906,000	Toledo Edison-Cleveland Electric Illuminating Co.	1975
Painesville	Perry Nuclear Power Plant: Unit 1	1,205,000	Cleveland Electric Illuminating Co.	1979
Painesville	Perry Nuclear Power Plant: Unit 2	1,205,000	Cleveland Electric Illuminating Co.	1980
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 1	810,000	Cincinnati Gas & Electric Co.	1977
OREGON				
Prescott	Trojan Nuclear Plant: Unit 1	1,130,000	Portland General Electric Co.	1975
Boardman	–	1,200,000	Portland General Electric Co.	1980
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station: Unit 1	40,000	Philadelphia Electric Co.	1967
Peach Bottom	Peach Bottom Atomic Power Station: Unit 2	1,065,000	Philadelphia Electric Co.	1973
Peach Bottom	Peach Bottom Atomic Power Station: Unit 3	1,065,000	Philadelphia Electric Co.	1974
Pottstown	Limerick Generating Station: Unit 1	1,065,000	Philadelphia Electric Co.	1978
Pottstown	Limerick Generating Station: Unit 2	1,065,000	Philadelphia Electric Co.	1980
Shippingport	Shippingport Atomic Power Station: Unit 1	90,000	Duquesne Light Co.	1957
Shippingport	Beaver Valley Power Station: Unit 1	852,000	Duquesne Light Co.-Ohio Edison Co.	1974
Shippingport	Beaver Valley Power Station: Unit 2	852,000	Duquesne Light Co.-Ohio Edison Co.	1978
Goldsboro	Three Mile Island Nuclear Station: Unit 1	819,000	Metropolitan Edison Co.	1974
Goldsboro	Three Mile Island Nuclear Station: Unit 2	905,000	Jersey Central Power & Light Co.	1976
Berwick	Susquehanna Steam Electric Station: Unit 1	1,052,000	Pennsylvania Power and Light	1979
Berwick	Susquehanna Steam Electric Station: Unit 2	1,052,000	Pennsylvania Power and Light	1981
Fulton Township	Philadelphia Electric Co.: HTGR No. 1	1,140,000	Philadelphia Electric Co.	1981
Fulton Township	Philadelphia Electric Co.: HTGR No. 2	1,140,000	Philadelphia Electric Co.	1983
SOUTH CAROLINA				
Hartsville	H. B. Robinson S.E. Plant: Unit 2	700,000	Carolina Power & Light Co.	1971
Seneca	Oconee Nuclear Station: Unit 1	841,000	Duke Power Co.	1973
Seneca	Oconee Nuclear Station: Unit 2	886,000	Duke Power Co.	1973
Seneca	Oconee Nuclear Station: Unit 3	886,000	Duke Power Co.	1974
Broad River	Virgil C. Summer Nuclear Station: Unit 1	900,000	South Carolina Electric & Gas Co.	1977
Lake Wylie	Catawba Nuclear Station: Unit 1	1,180,000	Duke Power Co.	1979
Lake Wylie	Catawba Nuclear Station: Unit 2	1,180,000	Duke Power Co.	1980
TENNESSEE				
Daisy	Sequoyah Nuclear Power Plant: Unit 1	1,140,000	Tennessee Valley Authority	1975
Daisy	Sequoyah Nuclear Power Plant: Unit 2	1,140,000	Tennessee Valley Authority	1975
Spring City	Watts Bar Nuclear Plant: Unit 1	1,169,000	Tennessee Valley Authority	1977
Spring City	Watts Bar Nuclear Plant: Unit 2	1,169,000	Tennessee Valley Authority	1978
Oak Ridge	Fast Breeder Demonstration Plant	400,000	Tennessee Valley Authority	1980
TEXAS				
Glen Rose	Commanche Peak Steam Electric Station: Unit 1	1,150,000	Texas Utilities Services Inc.	1980
Glen Rose	Commanche Peak Steam Electric Station: Unit 2	1,150,000	Texas Utilities Services Inc.	1982
Newton County	Blue Hills: Unit 1	918,000	Gulf States Utilities	1980
VERMONT				
Vernon	Vermont Yankee Generating Station	513,900	Vermont Yankee Nuclear Power Corp.	1972
VIRGINIA				
Gravel Neck	Surry Power Station: Unit 1	788,000	Virginia Electric & Power Co.	1972
Gravel Neck	Surry Power Station: Unit 2	788,000	Virginia Electric & Power Co.	1973
Mineral	North Anna Power Station: Unit 1	898,000	Virginia Electric & Power Co.	1974
Mineral	North Anna Power Station: Unit 2	898,000	Virginia Electric & Power Co.	1975
Mineral	North Anna Power Station: Unit 3	907,000	Virginia Electric & Power Co.	1977
Mineral	North Anna Power Station: Unit 4	907,000	Virginia Electric & Power Co.	1978
Gravel Neck	Surry Power Station: Unit 3	882,000	Virginia Electric & Power Company	1980
Gravel Neck	Surry Power Station: Unit 4	882,000	Virginia Electric & Power Company	1981
WASHINGTON				
Richland	N-Reactor/WPPSS Steam	800,000	Atomic Energy Commission	1966
Richland	WPPSS No. 1	1,120,000	Washington Public Power Supply System	1980
Richland	WPPSS No. 2	1,103,000	Washington Public Power Supply System	1977
WISCONSIN				
Genoa	Genoa Nuclear Generating Station	53,200	Dairyland Power Cooperative	1971
Two Creeks	Point Beach Nuclear Plant: Unit 1	497,000	Wisconsin Michigan Power Co.	1970
Two Creeks	Point Beach Nuclear Plant: Unit 2	497,000	Wisconsin Michigan Power Co.	1972
Carlton	Kewaunee Nuclear Power Plant: Unit 1	541,000	Wisconsin Michigan Power Co.	1973
PUERTO RICO				
Puerto De Jobos	Aguirre Nuclear Power Plant	583,000	Puerto Rico Water Resources Authority	1979

* Site not selected.

*	–	1,128,000	Tennessee Valley Authority	1980
*	–	1,128,000	Tennessee Valley Authority	1981
*	–	1,128,000	Tennessee Valley Authority	1980
*	–	1,128,000	Tennessee Valley Authority	1981

Figure 1. Nuclear power reactors in the United States, June 30, 1973—continued

Reported Nuclear Detonations, August 1973

(Includes seismic signals presumably from foreign nuclear detonations)

Seismic signals, presumably from a Soviet underground nuclear explosion, were recorded by the United States on August 14, 1973. The signals originated at approximately 10:00 p.m. (EDT), in the southern part of the U.S.S.R. northwest of Tashkent, and were equivalent to those of an underground nuclear explosion in the yield range of 20–200 kilotons.

An August 27, 1973, the United States recorded seismic signals, presumably from a Soviet underground nuclear explosion. The signals originated from the northern Kazakh Desert and were equivalent to those of an underground nuclear explosion in the yield range of 20–200 kilotons.

There were no reported nuclear detonations for the United States for August 1973.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

ENVIRONMENTAL MONITORING AND DISPOSAL OF RADIOACTIVE WASTE FROM U.S. NAVAL NUCLEAR-POWERED SHIPS AND THEIR SUPPORT FACILITIES, 1972. *M. E. Miles and G. L. Sjoblom. Radiation Data and Reports*, Vol. 14, September 1973, pp. 517–525.

The environmental effect of disposal of radioactive wastes originating from U.S. Naval nuclear propulsion plants and their support facilities is assessed. The total radioactivity discharged to all ports and harbors from the more than 100 nuclear-powered ships and supporting tenders, bases and shipyards was less than 0.002 curie in 1972. This report confirms that procedures used by the Navy to control releases of radioactivity from U.S. Naval nuclear-powered ships and their support facilities are effective in protecting the environment and the health and safety of the general public.

KEYWORDS: Discharges, disposal, harbors, monitoring, nuclear-powered ships, radioactivity, U.S. Naval, wastes.

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